UNIVERSITY OF BRISTOL.

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT & CIDER INSTITUTE),

LONG ASHTON, BRISTOL,

1920.

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INTRODUCTION.

The following record of the work of the Station for the year 1920 is somewhat less complete than usual. There are a number of papers dealing with individual investigations which are awaiting publication, and the work dealt with therein will not be summarised in Report form until the original papers have appeared. Brief mention only is made of several lines of work to which much time has been devoted, the problems concerned being difficult and consideration of results being inadvisable until a larger body of evidence has been accumulated. The actual amount of research progress during the year has also been materially checked in several directions owing to the almost continuous attention which the largely increased advisory work has required from the staff generally.

The year as a whole has been marked chiefly by progress of a more or less preparatory character. Most of the present members of the research staff have joined the Station since the spring of 1919; a large area of land has become available for planting; and the older plantations have required overhauling. To meet the altered conditions, rearrangements in internal organisation have had to be made, extra working space in the laboratories has been provided, and the entire system of plantation work has been recast. The Station has thus been passing through a period of transition from practically the pre-war scale of operations, with its four members of the research staff and limited holding of land, to that now reached under which, including assistants and workers not directly attached to the staff of the Station, there are now 17 workers mainly occupied with research and over 200 acres of land awaiting development in addition to the area already planted with fruit. The effect of this extension of activity is only just beginning to be felt, but in due course there should be a decided advance in the output of results.

Staff.—With regard to staff changes during the year, the only loss the Station has sustained is that of Mr. C. T. Gimingham, whose impending departure was referred to in last year's Report.

The following additions have to be recorded: Mr. G. S. Peren, B.S.A., Toronto, has been appointed Pomologist of the Station. After the termination of the war he spent several months at the East Malling Fruit Research Station, assisting in the pomological in-

vestigations in progress there, and subsequently joined the staff of the Horticulture Division of the Ministry of Agriculture and Fisheries. He resigned his appointment there to take up his duties at Long Ashton last March. He brings with him useful experience of North American methods of fruit culture, having studied the subject at Guelph Agricultural College and Vineland Experiment Station, Canada, and engaged in practical fruit farming in various parts of that country before joining the Army at the outbreak of war.

Mr. F. Tutin has been appointed Bio-chemist. His early scientific training was received at University College, Nottingham. Prior to entering the Army he held the position of Deputy Director of the Wellcome Chemical Research Laboratory. During the war his health broke down as a result of work on explosives, and he was then transferred to the staff at the Lister Institute engaged on bio-chemical investigations. With his assistance it will now be possible to undertake new lines of work on some of the chemical processe involved in the growth of fruit trees and the development of fruit which have hitherto had to be deferred because of the lack of an organic chemist on the staff.

For a similar reason, some of the problems of fruit culture which must be attacked from the side of plant physiology can now be taken up. Mr. F. Summers, D.S.O., M.C., M.Sc. (Liverpool), B.A. (Camb.), B.Sc. (Lond.), has accepted an appointment in that subject and came into residence at Long Ashton in the early spring of 1921 on his return from Ceylon, where he has been engaged on botanical work for the Colonial Office. He is a graduate of London University, and has pursued post-graduate studies at the Universities of Liverpool, Zurich and Cambridge, holding one of the Ministry of Agriculture Research Studentships at the latter place until he entered the Army in 1914. After a distinguished career in France during the war he returned to Cambridge to work under Professor R. H. Biffen, F.R.S., before taking up his appointment in Ceylon.

The closing down of the Woburn Experimental Fruit Farm, which had been maintained since its opening in 1895 until recently by the Duke of Bedford, and conducted under the direction of the late Mr. Spencer Pickering, F.R.S., has enabled Mr. W. H. Neild, its manager since 1904, to join the staff at Long Ashton. He will act as Experiments Officer and Recorder for the outdoor work at the Station, a position for which his career at Woburn provides him with unique experience and qualifications. This arrangement fortunately ensures that touch with the valuable work which has been conducted in the past at that Institution need not be entirely lost, and that certain important subjects of investigation requiring further study can be proceeded with at Long Ashton with some measure of continuity.

Although not definitely attached to the staff of the Station, the following are temporarily associated in one capacity or another and are participating in various branches of the work.

Mr. C. P. Dutt, B.A., is continuing his investigations on certain chemical changes occurring during the ripening of fruit which, as reported last year, he is conducting at Long Ashton for the Food Investigation Board.

Miss Violet G. Scott and Miss Watson, the technical members of the staff of the Campden Experimental Factory, have been temporarily stationed at Long Ashton and engaged on preparatory work in connection with methods of fruit and vegetable preservation. The factory mentioned, which is located at Chipping Campden, Glos., is now being equipped to serve as the centre for commercial scale experiments and trials on this subject. Hitherto this work has been done under temporary conditions at Dunnington and Broom Junction. The Fruit Preserving and Vegetable Drying Committee, appointed by the Ministry of Agriculture and Fisheries, is responsible for the administration of the scheme and Long Ashton has been requested to undertake the initial laboratory investigations involved, as well as the supervision of the scientific side of the trials conducted at the factory. In future, therefore, there will be a close association between the staffs of the two centres and the facilities for work at either place will be available for both.

Miss Gilchrist, B.Sc., one of the Demonstrators of the Botanical Department of Bristol University, has recently started research in collaboration with Mr. Wiltshire, the Mycologist of the Station, on fungoid diseases of fruit trees. She is devoting attention in the first place to the disease of apple trees caused by a species of Myxosporium, referred to by Mr. Wiltshire in a preliminary note later in the present Report.

During the coming year it is hoped and expected that closer touch will be arranged between individual Departments of the University and the Institute which will lead to other cases of joint work of this kind. The Physics Department, through Professor Tyndall, has already rendered valuable help by making an examination of the physical properties of Spondite, a material lately introduced as an alternative to glass for horticultural purposes. This was required as a preliminary to comparative tests on growing plants which are being arranged at Long Ashton at the desire of the Chamber of Horticulture.

Mr. H. W. Miles, N.D.A., who until recently was a member of the staff of the Harper Adams Agricultural College and has now entered Bristol University as a research student, is devoting himself to investigations on certain insect pests of fruit trees in association with Mr. Lees.

Land and Plantations.—In the way of development the out-

standing event of the year has been the purchase of Fenswood Farm. The approval of the Development Commission and the promise of a grant from the Development Fund were recorded in the last Report, but various causes of delay prevented the completion of the purchase until the end of the year. It has been decided not to take over the whole farm at once from the existing tenant on account of the difficulties which would be involved in starting farming operations on a large scale under the present difficult financial conditions. About 40 acres adjoining the present fruit plantations are, however, being attached to the Station immediately and prepared for fruit as quickly as possible. There is now no longer any need for its field work to be held up for want of land in the way that it has hitherto been since its foundation and already the establishment of a number of new plantations can be recorded.

The first of the larger root-stock trial plantations was planted early in the year. The stocks being tested are the types of Paradise apple which have been selected at the East Malling Station, and the varieties of apples which have been worked upon them are Bramley's Seedling, Lane's Prince Albert and Worcester Pearmain. Similar trials are being conducted at East Malling and a few other centres where local conditions are distinct, and in the course of a few years useful information as to the respective merits of the individual stocks should be forthcoming. Concurrently with the field trials the investigations on the nature of root-stock influence, which were started some years ago, are being actively proceeded with.

Both this work and, more particularly, that on fruit-bud formation, which has been referred to in recent Reports, as well as several other problems, such as susceptibility to disease, have indicated the desirability of a much closer investigation of root action as a general subject than has previously been made at any of the fruit research centres. Various phases of the subject are now under examination at Long Ashton and a further extension is proposed for the coming year. One of the first points being studied is the history of the development of the root-system of the tree and its relation to root growth. A special plantation of apples on Paradise root-stocks has been established for that purpose and an account of the first season's observations, together with those of concurrent series of trials in sand and water culture, will be found in the present Report.

Last planting season also a three-acre plot of apples of the Allington Pippin and Edward VII varieties was planted up for manurial trials. These will be conducted in conjunction with manurial experiments on fruit trees in pots designed to furnish information as to the effect of individual constituents, such as

nitrogen, potash and phosphates, on the health and fertility of the tree. Analagous trials with soft fruits are being arranged and a three-acre plot of gooseberries is being planted up with this object during the current planting season. The very varied results of manurial trials on fruit which have been reported from time to time both in this county and abroad suggest that it is imperative to give particular care to the arrangement of individual plots and the elimination of risk of overlapping effect between adjacent plots. Some information as to the root range of the trees under treatment is accordingly essential and a detailed examination as to the spread of the root-systems of individual trees of various ages is, therefore, now in progress at Long Ashton. Results already show that the area tapped by a single tree of comparatively young age is very considerable and much more than expected. Even in cases of trees two years old only on Rivers' English Broad-leaved Paradise stock planted in early 1920 a completely new root-system with a circular spread of over a yard radius has been observed after one season's growth only.

Other plots of apples established last planting season include trial plots of seedlings which have been raised in the course of the fruit-breeding work, a variety trial plantation of some of the newer and more uncommon varieties which have not been previously tested, small plots of Bramley's Seedling, Lane's Prince Albert and Allington Pippin for special experiments required in connection with the fruit-bud investigations, and a small plot for the examination of the effect of double-grafting.

In addition, sixteen acres of land are now in course of preparation for an extensive experiment concerned with pruning and other methods for regulating growth and cropping of apple trees, for field investigations on the double-working of pear trees, for various field trials in connection with the problems of root growth and influence in apples, pears, and plums, and for testing the effect of pedigree bud strains for the same group of fruits.

During the current planting season a new 12-acre cider and perry orchard is also being established. This is being devoted to an examination of some of the more important problems which occur for grass orchards grown under farm conditions, such as the production of stout standard trees capable of withstanding damage from grazing live-stock, the maintenance of healthy growth in grass, and disease and pest control. The varieties selected will for the most part be those which were recommended in the last Annual Report for farm orchard work. A part of the orchard will be devoted to a selection of suitable table varieties of apples and pears, such as Bramley's Seedling, Annie Elizabeth and Newton Wonder, which promise to be profitable sorts under farm orchard conditions.

Arising in this connection, it may be mentioned that the Farm Orchards Committee has had under consideration during the year the report on the survey of West of England farm orchards which was referred to last year. A series of recommendations for the improvement of these orchards has been submitted to the Ministry of Agriculture and Fisheries, and the latter is proposing to take steps to give effect to them on the lines of a scheme which has already been prepared in draft form.

Several new plots of soft fruits are being provided. In the case of strawberries, a series of small plots designed to furnish information on the question of factors influencing cropping quality has been started. A one-acre plot of raspberries has been planted to serve a number of distinct purposes. A very comprehensive collection of varieties, including leading Continental and American kinds, has been secured and it will function as (*a*) a variety trial, (*b*) a reference plot for the systematic work on the classification of the raspberry group of fruits which is now in hand, (*c*) a source of material required for fruit breeding investigations and (*d*) a source of fruit required for variety tests in canning, bottling and other methods of fruit preservation.

For the further study of reversion and control of " big bud " in Black currants room has been found in the cultivated portion of the experimental cider orchard adjoining the main buildings for a two-acre plot of young bushes.

The three-acre manurial plot of gooseberries has already been referred to.

Small plots have also been provided for the respective groups of seedlings of the soft fruits already raised in the course of the fruit breeding work.

Much has been done during the year in the older plantations to adapt them for special purposes. To a very large extent the objects for which they were originally planted have already been served and some have outlived their usefulness for further experimental work. In nearly all cases the trees were planted too close to permit of reliable results when fully grown. With younger plantations growing up to take their place and land available for further extension the need for retention in their original form has passed. Drastic alterations have therefore been made. Where it has been necessary to retain material to serve until younger trees are ready, this has been done, although, where convenient, wholesale thinning has then been practised to permit of horse cultivation in the place of hand work for reasons of economy. Trees no longer fit to serve any useful experimental purpose have been scrapped and the land applied to better advantage. Most of the older trees retained are being reserved for disease control experiments. In some plantations the opportunity of preliminary work on cover cropping methods is being taken.

Buildings.—No new buildings have been erected during the year, although a few minor alterations have been made in some of the existing structures. The original building scheme decided upon in 1912 has, in the case of the cider house, never been completed owing, in the first place, to the outbreak of war and, subsequently, to the serious increase in cost of building. It had been intended to modify the old wing of the cider house to provide a more convenient mill and press room, a fruit loft equipped with fruit-washing apparatus and small fermentation rooms with temperature control. There being no immediate prospect of proceeding with the scheme, a small loft in the building has been adapted to serve temporarily as a warm fermentation chamber in time for the current season's work. It is recognised that adequate provision for fruit-washing must be made and an effort is being made to devise a scheme of arranging this which will not entail a too heavy outlay. A rather crude and not over efficient expedient is being tried as a temporary makeshift.

The present fruit room used for the storage of the market fruit crop grown at the Station is located in the old wing of the cider house, the original cider cellar having some years ago been adapted for the purpose when the present cellar was built in the new wing. The quality of the storage is not sufficiently good nor the space available adequate to take all the crop in full seasons. With a considerable acreage of young apple and pear trees likely to come into bearing within a few years, some more commodious and efficient storage must soon be provided. The character of the new store has not yet been decided upon. In view of investigations on systems of fruit storage which are now being conducted by the Food Investigation Board, it seems advisable to defer taking definite action for a while to await the outcome of this work. Cold storage methods are being tested in London and also at this Station. A cold store equipped with the necessary refrigerating plant has recently been erected here for this work, the cost being borne by the Food Investigation Board. It is divided into three compartments, the larger having a capacity of 1000 cubic feet, and the two smaller of 160 cubic feet each. The temperature is maintained by means of currents of cooled air and can be regulated by simple adjustment of inlet and outlet valves. The arrangement is such that each of the three compartments can be maintained at different temperatures. Another section of this work is being conducted at Cambridge, where attention is being mainly given to gas storage methods which are yielding results of great interest and economic possibilities.

The pressure on the laboratory accommodation, due to the increase in the number of research workers, has already been indicated. Some relief has been gained by transferring the quarters of those

members of the research staff whose work lies mainly in the fruit plantations to two rooms in the office buildings, one of which was until recently occupied by the Live Stock Officer for the Bristol Province. More office accommodation also being needed, another room has been converted into an extra office, and the whole building is now used exclusively for these purposes. By this rearrangement it is hoped that the present laboratories, with but slight internal alterations, may be made to serve until further increase in staff, which is unlikely for some time ahead, makes extension imperative.

General.—Although the developments of the Station in the direction of general farming, which follow as more land comes under its control, do not come strictly within the purview of this Report, reference ought to be made on this occasion to the very successful herd of Gloucester Old Spot Pigs which has been built up within the last three years. Not only were entries at the Royal and Bath and West Shows in 1920 placed at the head of their respective classes, but also the sale of surplus animals in August reached a remarkably high level, the average price per head being £65. At the representative gathering of agriculturalists who assembled on that occasion frequent reference was made to the useful part which the Station was playing in raising the standard of the Breed and presenting an example to farmers of the right lines on which to proceed. For these results Mr. W. Nixon, the late Live Stock Officer for the Bristol Province, whose personal help in establishing the herd and whose advice so willingly given at all times have been such factors in the success, and Mr. E. P. West, the Secretary-Manager of the Station, whose enthusiasm and judgment have been of inestimable service and under whose charge the work has been, have mainly to be thanked.

The Annual Tasting Day was revived in 1920 after a lapse of two years, the date being May 6th, the first Thursday in the month, in accordance with the usual practice. Both as regards size of attendance and the amount of interest shown in the work of the Institute the occasion ranked probably as the most successful of the series.

Educational exhibits illustrating the results of various investigations in progress at Long Ashton were sent to the Bath and West Society's Show at Salisbury, the Summer Provincial Show of the Royal Horticultural Society at Cardiff, the Summer Show of the Pershore and District Fruit Growers' Association, and the West Midland Commercial Fruit Show at Worcester. The interest taken in the exhibits on these occasions indicates that this is a side of the work of the Station which should not be neglected; but on the other hand the cost in time and money, both in preparation and at the shows themselves, is so considerable that some limit must be imposed. Most of the shows in the Western area unfortunately come at a

time of the year when fruit research is in full swing and members of the staff cannot be away from Long Ashton then without detriment to the work in progress.

Another method of bringing fruit growers and others interested into touch with the work of the Station was referred to in a preliminary way in the last Annual Report. The scheme in contemplation was the extension of the Governing Body of the Institute by the inclusion of representatives directly nominated by the larger fruit growers' Associations in the West of England, and a few of the most important outside that area. Representation of other bodies belonging to certain related industries and of various research organisations was also to be sought. These proposals were unanimously adopted by the Governors of the Institute and the following additions to the list of Governors have already been made :—

G. F. Glenny, Esq. (representing the Wisbech and District Fruit Growers' Association).

H. S. H. Bickham, Esq. (representing the Herefordshire Fruit Growers' Association).

H. P. Pollard, Esq., J.P., F.R.H.S. (representing the Evesham Fruit Growers' Association).

S. J. Shackell, Esq. (representing the Pershore and District Fruit Growers' Association).

J. W. Humphries, Esq. (representing the Cheddar Valley Fruit Growers' Association).

E. W. Bond, Esq. (representing the National Association of Cider-makers).

Professor V. H. Blackman, F.R.S. (representing the Imperial College of Science and Technology, South Kensington, S.W.).

F. J. Chittenden, Esq., F.L.S., V.M.H. (representing the Royal Horticultural Society).

Professor W. Bateson, D.Sc., F.R.S. (representing the John Innes Institute).

R. G. Hatton, Esq., M.A. (representing the East Malling Fruit Research Station).

It will be noted that the name of the Director of the East Malling Fruit Research Station, Mr. R. G. Hatton, M.A., appears in this list. The desirability of bringing the work of the two existing Fruit Research Stations maintained by grants from the Ministry of Agriculture into close association is obvious and this has now been secured in some measure by the inclusion of the Director of either

Station on the Governing Body of the other. A still more intimate link may be found desirable in order to facilitate mutual assistance, economical working, and avoidance of unnecessary overlapping at the two Stations. This matter is at present under consideration.

The separate sections of the Report which follow consist of summarised accounts of individual investigations which have been in progress during the year, the names of the members of the staff conducting them and responsible for the contribution appearing at the head of each section. A general acknowledgment of the help rendered by the Administrative Staff and the Assistant Staff of the various Departments concerned may be fittingly made at this point.

Since several subjects which have received attention are not being dealt with in detail on this occasion for reasons already stated, the following brief notes on the nature of the work in some of these cases are given to indicate somewhat more completely the programme of work in hand.

The Fungicidal Action of Sulphur.

The phase of this investigation which has now been reached involves the accurate estimation of amounts of volatilised sulphur present in the atmosphere of compartments which have been subjected to sulphur treatment. Much time has been occuiped in discovering a chemical method sensitive enough to register with a sufficient degree of accuracy the minute quantities which have to be determined. One which promises to be satisfactory consists in the oxidation of the sulphur to sulphuric acid by the action of dry bromine and concentrated nitric acid, followed by estimation as barium sulphate. There has been some difficulty in getting fair samples of atmospheres to be tested, but a form of procedure has now been devised which promises to yield uniform results. The determination of lethal doses of volatilised sulphur carried in the atmosphere can now probably be very soon proceeded with.

The experiments suggest that concentrations of sulphur of the order of one part of sulphur to 100,000 parts of air may be estimated with a fair degree of accuracy.

The Pectic Substances of Fruits.

The significance of these substances in connection with the ripening processes of fruits is undoubted and they must be considered as playing a very important, if not determining, part on the keeping quality of fruit during storage. Not only, however, is the character of the transformations undergone during ripening doubtful, but the chemical nature of the individual substances themselves is still little understood. During the course of the recent work of

Mr. Tutin and Mr. Dutt on these points appreciable progress has been made, the relationship between pectin and pectic acid having been demonstrated and quantitative data as to the variations in amounts of these substances at different stages of ripening of fruit secured.

Leaf Scorch.

This affection of the foliage of many kinds of fruit trees and of other plants was referred to in a preliminary paper in the 1915 Report. It appears, at any rate so far as the leaf is concerned, to be independent of the presence of any parasitic organism and must accordingly be classed among the so-called physiological diseases. Although during the war little could be done on this question from the experimental side, a considerable amount of information was collected relating to the characters of individual outbreaks and the nature of the soil and other local conditions in the affected cases. For the most part the data refer to cases on apple trees. The trouble is so widespread and the check to growth so serious in many cases that it has been felt that further investigation ought to be no longer postponed. Soils of affected areas of land have been taken for both chemical and biological examination and their composition is being compared with that of similar formations which do not show the scorching effect. One point which appears to be established already is that the root-system at the season of the year when scorching is most pronounced seems in a definitely unhealthy state. So far it has not been found possible to reproduce the trouble in typical form under experimental conditions, although a kind of scorch has at times been produced. An extensive series of experiments, based on ideas suggested by observed facts, has been planned for the coming season and it is hoped that they may throw some further light on the trouble.

Factors Governing Fruit-Bud Formation.

The last Report carried the story of this work to the point where the ringing and notching of branches of fruit trees were shown to produce definite effects both above and below the point of treatment. It was shown that the observed facts could be explained by Loeb's hypothesis of the presence of a growth-inhibiting substance or toxin. Subsequent work has been directed to a further examination of this hypothesis and it is considered that the facts now available can be interpreted on the whole more satisfactorily by it than by the alternative hypothesis, which attributes the results to actual deficiency of food. During the course of the work several interesting questions affecting nutrition generally have been opened up and these are being further examined.

Investigations on Fruit Preserving.

There have been two main lines of work under this head which have been given particular attention during the past fruit season.

The first is that of preserving fruit for storage prior to its conversion into jam. Normally it is pulped by the action of steam and stored in casks, various sulphite preservatives being used to prevent subsequent fermentation and mould growth. This method, while simple and efficient if proper care is given to the stored material, nevertheless appears wasteful of heat and often results in considerable loss due to deterioration of the pulp through neglect to maintain the dose of preservative at the necessary strength. The results of experiments recently made suggest that it may not be difficult to devise a practical method which will give an improved product at less cost.

The second main line of work has to do with the preparation of jams and jellies by a cold process. The advantages of such a method, if practicable, are obvious. The cost of heating would disappear, the fresh fruit flavour would be retained unimpaired and the vitamine content of the fruit would probably remain undestroyed. The experiments have shown that the project is feasible, that a product of high quality can be prepared and that some of the obvious practical difficulties can be overcome. Whether any of the remainder will prove insuperable must be left for further investigation to determine.

FACTORS GOVERNING FRUIT-BUD FORMATION.

By B. T. P. Barker and A. H. Lees.

IV.—Pruning.

A. THE LORETTE SYSTEM AS APPLIED TO ENGLISH CONDITIONS.

The last two articles of this series (II and III) treated respectively of "the normal phase of growth" and "the effects of ringing and notching." The subject of pruning follows in natural sequence. It is altogether too large and too complex to be dealt with adequately within the limits of a single article, and much further experimental work is necessary before it can be profitably considered in a general way. The kind of response a tree makes to any form of pruning is determined by the combined action of numerous factors and these operate in varying degrees under different conditions. Often rules that suit one place or variety are unsuited to another place or variety. To place pruning on a scientific basis the principles underlying the process must first be elucidated. Then it should be possible to lay down general rules capable of modification for different conditions.

Primarily pruning consists in the removal of complete portions of the tree in such a way as to interfere with its normal course of growth and intelligent pruning aims at causing a desired proportion of the remaining buds to develop into flower rather than wood buds. In the case of the apple and pear there is no special time at which the operation must be done. Both winter and summer have their advocates, and pruning at any time will produce in a healthy tree some reaction, though this may and will vary according to a number of conditions.

Previous experience has shown that attempts to advance the knowledge of the subject by the method of set pruning experiments or tests of one system against another have failed to strike at the heart of the subject because attention has been focussed on the response of the tree as a whole to the combined influence of the individual factors which come into play. Their joint force is necessarily a variable one, determined by the local conditions

prevailing during the course of the experiment. At Long Ashton a different method is being adopted, which consists essentially in a study of the interplay of the various factors concerned when a definite form of treatment with a specific object is adopted.

The various divisions of the present article are limited therefore to a consideration of certain processes of pruning in so far as they modify fruit-bud formation only, and secondary and tertiary effects are neglected. The processes treated on this occasion constitute the Lorette system. It has been selected for prior consideration, partly from its inherent interest, partly because many growers have expressed the desire for a short account of it in view of its bearing on their practical methods, and partly because it serves as a convenient starting point for further discussion of the problems of pruning generally.

Section I.—The Lorette System of Pruning.

"La Taille Lorette" was the title of a book, the first edition issued in 1913 and the second in 1914, giving the results of the author over a period of years. The book itself is distinctly difficult to understand, though this is not so much due to the fact of its being written in French as that the arrangement of the matter is faulty. Sometimes indeed one is tempted to think that there is no arrangement at all and the reader may easily become greatly confused as to the real meaning of the author. The position is rendered still more difficult by the fact that there is no recognized translation for many of the technical terms. Nevertheless an effort has been made here to give the gist of Lorette's directions in so far as they affect flower production as distinct from training and, if errors have crept in, they are due to the difficulties above outlined. It may be mentioned at once, so as to dispose of the subject, that his directions for training trees are not likely to be of much assistance to commercial fruit growers, since in nearly every case some sort of supporting structure is specified. There is, however, one exception and that is the "fuseau" or "distaff" form which, quite conceivably, may oust the cordon, since no support is necessary and fruit is obtained only one year later and then in greater quantity. In this article, however, this form will not be considered.

Lorette aims at producing his flower buds and spurs only on main supporting branches. Any twig or branch of a wood-shoot nature that does not definitely extend the intended frame work of the tree has to be treated in some way or other to induce it to change into or produce flower buds. He admits of no secondary or breast wood in the ordinary sense and his system must be classed as a spur system. He is thus always striving to make the tree consist of the two types of shoot, viz., supporting branches

and spurs. (As an amplification of spurs in the ordinary sense are his "coursonnes" which are, however, roughly only what are generally called compound spurs. All his intermediates are temporary forms.)

At present a few commercial growers practise a spur system, but such methods have generally been considered by many to be more suitable for amateurs' gardens than for commercial plantations on the supposition that more labour is entailed. Most growers leave intermediate or secondary small branches where there is room for them under the idea that they will fruit naturally. They do sometimes. Often, however, flower buds only form at the terminal and the resultant fruit may then, owing to winds, be knocked off prematurely. In many cases, however, these secondary branches end in a wood bud and simply continue wood growth the following year. In certain cases the practice may be justified, especially in certain varieties for definite purposes, but its general practice causes the bush to lose definite shape and no distinction can then be made between supporting branches and secondaries. The final result is that these secondaries usurp the function of supporting branches, but they are in an entirely wrong position for carrying on this function. Lorette himself does not consider the bush form to be acceptable, but since there is general agreement amongst English growers that it is a desirable form, and since it has many practical advantages, it is necessary to consider how far Lorette's flower production methods can be applied to it. The junior author has grown bush apples in his own garden for five years under Lorette's treatment and is entirely of the opinion that the general method, with modifications, is quite suitable. The question is, of course, to some extent necessarily bound up with training, but for the sake of clearness this need not be discussed here. One must presuppose that conditions of light and supply of crude food are satisfactory and then the problem simplifies itself into how to change wood shoots other than those destined to form supporting branches into spurs. By a spur is meant a short shoot bearing one or more flower or intermediate buds (dards).

First of all Lorette lays importance on the cutting of the leaders when the "sap is in motion," and for pears, of which his book chiefly treats, the date comes generally some time in April. He maintains that better results are obtained in this way, especially as regards stimulation of the more dormant buds at the base of the leader.

His rules for subsequent treatment may be laid down as follows. It must be remembered that they apply to pears and that for apples the operations have to be done about three weeks later.

All cuts of shoots that are not leaders are made with secateurs. Leaders are not cut after the April-May prune.

I. Treatment of Wood Shoots.

(*a*) *Of one year's growth only* (*namely shoots which arise directly from a supporting branch and thus consist of current year's growth only*), *when these are*

(1) *about the thickness of an ordinary lead pencil at the base*

(2) *about* 10-12 *inches long, and*

(3) *just beginning to lignify at the base.*

Cut to "empâtement."

Of these three methods of telling whether an ordinary shoot is ready for cutting the third is far the most important. In practice one finds that, except in particularly strong varieties, the shoot when ready for the operation is slightly less than pencil thickness. The length also varies. Thus in really weak growers the shoot is suitable long before it is ten inches in length. The third method, however, is a safe criterion. It must neither be green and sappy nor hard and woody, but just in between. The first two methods apply to training much more than to flower production. In Lorette's book they are confused, but those who have talked with him say that the third criterion is by far the most important when pruning for flower production.

"*Cut to empâtement.*" According to Lorette's figures this means cut to the one or two leaves at the base. In another part of his book he clearly says that a centimetre of tissue must be left. In yet another he defines the operation as a cut "au-dessus les folioles." The "folioles" are the leaves at the base which do not contain a visible eye at the time of cutting. The cut to "empâtement" thus becomes a cut just above the highest leaves not containing an eye at the time of cutting. In many parts of his book he emphasizes the importance of this cut in developing the stipulary eyes. These are paired dormant eyes on each side and at the base of the primary shoot. Here again there is confusion. Apparently they are to be developed when one is following his advice for training specimens. For flower formation they are not so important, though if they develop as the result of a cut they are useful. Two persons who have seen him separately, state that it is the "basal cluster" that he really advises for pruning to.

The term "basal cluster" requires some explanation. If ordinary wood shoots of an apple or pear be examined in the middle of summer it will be found that in most the leaves are more crowded at the base than elsewhere. Often in the first inch or so there are as many as five leaves, whereas on the higher parts of the shoot they average perhaps one per inch. This cluster of leaves at the base goes by the name of the "basal cluster." In other shoots, however,

the " basal cluster " can scarcely be recognised, the base of the shoot having the appearance of having being pulled out longitudinally. All kinds of intermediates may be found between the well developed " basal cluster " and no cluster at all. The leaves of the " basal cluster " have no visible eye at the time of pruning and so Lorette's rule comes down to this :—*prune to the " basal cluster."*

In the pear the first of such shoots to require attention are those immediately behind the pruning cut of the leader and the time, the middle of June. If secondary wood shoots arise from stipulary eyes or from the " basal cluster " they are cut in the same way in July-August, and tertiary, if any, in August-September.

Most of the wood shoots will not be ready for cutting until the end of June. Secondary and tertiary shoots are treated as above in July-August and August-September.

[NOTE.—If wood shoots do not attain pencil thickness by the end of June (for pears) a different treatment is given. Such shoots are cut to three leaves possessing eyes. Usually the two top buds grow out. When the top shoot is 10–12 inches long it is completely removed and the second shoot is cut to " empâtement." The third eye then changes to a " dard " (intermediate bud between wood and flower).]

(*b*) *Of more than one year's growth (namely shoots not arising directly from a supporting branch, but a short piece of wood of one or more year's growth).*

Leave one wood shoot (the weakest) and cut it to one visible eye.

These are, of course, wood shoots growing from shoots treated in previous years. The whole organ therefore consists of the current year's wood growth and, at its base and bearing it, wood of an older year or years. This older wood will in nearly every case bear either developing flower buds or dards or both.

The wood shoot is cut to one visible eye. This eye acts as a sap drawer to prevent the dards or developing flower buds behind being pushed out into wood growth. If more than one such wood shoot is present, remove completely all except the weakest, which treat as above. If at any time a well-formed dard should grow into a wood shoot, cut right back to its basal cluster. Time of treatment about the end of June. In August–September remove all stubs of such cut shoots leaving only flower buds and dards.

II. Treatment of Spurs.

Leave if no wood shoot present. If present cut as in I (b).

A treated wood shoot of the previous year really becomes an incipient spur and it is difficult to say where one grades into the other. Such a shoot in the second year may or may not possess developing flower buds, but it certainly should possess dards.

III. Treatment of "Brindilles" or Twiggy Shoots.

Cut to three eyes or bend downwards.

Lorette defines a "brindille" as "a slender branch crowned with a rounded eye which bears fruit." There seems, however, some vagueness as to his exact meaning. Sometimes he uses the term in this sense and sometimes he applies it to any long thin twiggy shoot, even if its terminal is a wood eye. According to him they are unsuitable for cutting. These should be left to fruit in young and vigorous trees, but in fertile and less vigorous ones they should be cut to three eyed leaves at the end of June, as in I (*a*) Note. In another place he recommends bending such twigs downwards by an attached weight and partially cutting through the stem with an oblique cut between the third and fourth leaf. This operation is supposed to make the basal buds break.

IV. Treatment of "Bourses" or Knobs.

Cut wood shoots arising to the basal leaf or to two visible eyes.

When a flower is fertilized and sets fruit the portion of the plant tissue bearing the stalks enlarges (especially in the pear) to form the structure called a "bourse" or "knob." It develops two eyes, one on each side and one nearer the fruit than the other. These are, of course, the eyes that in an old tree develop naturally into flower buds for a subsequent season.
If wood shoots develop from the bourses they are treated as follows :—

(*a*) If no dards are present on the bourse, or if these dards only have 3–4 leaves, cut the wood shoots when 5–6 inches long preserving the leaves at the base.

(*b*) If dards with more than four surrounding leaves are present leave one sap drawer only, which cut to two eyed leaves. Both (*a*) and (*b*) are treated in early June.

V. August-September Treatment.

In August-September remove all stubs derived from previous prunings and leave only flower buds, dards and brindilles.

There are thus no wood shoots remaining except those which are forming supporting branches.

The following calendar for pruning operations on the pear, according to the Lorette system, is adopted from the one in his book.

April ... Cut leaders.
May ... ... Thin fruit, leaving only one per truss.

June ... ... Cut back wood shoots from the "bourses" according to directions.
Cut back strong wood shoots just behind pruning cut of leaders leaving about 1 cm. and preserving the "folioles."

June-July ... Cut back most of the wood shoots which had not attained the proper condition in June.
Cut thin ones to three eyes.
Cut back wood shoots from spurs or fruiting branchlets (coursonnes) to one eye if dards or developing flower buds present below; otherwise to cluster.

July-Aug. ... Cut back to cluster secondary shoots derived from wood shoots cut back at the first pruning.

Aug-Sept. ... Cut back tertiary shoots, if any, but not if they are feeble. Cut out all stubs from previous operations leaving only flower buds, dards and brindilles.

Section II. Survey of Results Under Long Ashton Conditions.

In the summer of 1915 the junior author began to put Lorette's principles into practice on some bush and cordon apples and pears at Long Ashton, and the following criticisms are based on the experience thus gained. He alone is responsible for them, and his results refer, unless otherwise stated, to Long Ashton conditions. It may be pointed out that these conditions differ from those of Worcestershire and Herefordshire, and still more from the East of England, in being markedly wetter. The probable influence of these conditions is discussed in a later portion of this paper.

1.—*The Importance or otherwise of Pruning Leaders in April.*

Lorette lays great emphasis on pruning leaders of pears and apples when the "sap is moving." This period for pears falls in April, and for apples about three weeks later. The criterion is that the lateral buds on the leaders should have made two inches of growth. He maintains that pruning at this late date causes a better "break" of buds from the basal part of the shoot than would otherwise be obtained.

These basal buds are always weaker and frequently require some extra stimulation to cause them to leave their rather dormant state. In ordinary winter pruning one finds that the harder the prune the more the basal buds tend to break, but on the whole fewer buds break. Thus if an unpruned shoot possessed 15 buds and 5 were removed in pruning something like 6 of the remaining 10 might break leaving 4 dormant. If, however, 10 buds were removed

leaving only 5 probably 3 would break strongly and 2 remain dormant. Thus the harder the prune the fewer the dormant buds at the base, but also the fewer that actually break. In the light prune there would be 6 buds breaking and 4 dormant, in the hard prune 3 breaking and 2 dormant. If the shoot therefore is left unpruned till April, it will break as an unpruned shoot, *i.e.*, there will be the maximum tendency for dormant buds. Therefore if Lorette's contention is to be maintained the better break should be obtained after his April prune. That is to say, after the prune there should be some evidence that the basal buds are given an extra stimulation. To prove the point, several pear shoots were pruned according to his directions and the position of the last basal bud to break carefully marked. No further basal buds broke as the result of the pruning cut nor were those weak basal ones that had already broken, at all stimulated. The result appeared therefore to be nil and in no way superior to what could be obtained by doing the same pruning in the dormant season. In two special cases, however, some such effect as Lorette contends do occur. The first may be got when a leader is cut back in April or early May, right behind any visible green bud on to bare wood. In this case a number of dormant eyes may be made to break. A somewhat similar stimulation, but this time of basal buds that are already incipient dards, can be obtained if a leader is cut to a bud that is itself nearly quiescent as regards growth. This can be done in May, by which time the dards at the base of last year's wood growth have practically closed buds. Before the new terminal is forced into new growth the buds behind have been measurably stimulated. It must be noted, however, that in each of these cases the new terminal is in an inactive or quiescent condition, whereas in the usual Lorette practice it is quite open and actively growing.

2.—*Pruning the Wood Shoots to "Empâtement."*

In the first two years of experiment at Long Ashton, Lorette's book directions were followed and the cut made to one or two basal leaves leaving 1 cm. of unpruned tissue as directed by him. The results were often very bad. Five possible things happened.

(*a*) Stipulary eyes developed and grew into dards. (Quite seldom.)

(*b*) Stipulary eyes developed and grew into thin woods shoots. (Frequent.)

(*c*) No stipulary eyes developed. Eye in axil of one of the basal leaves grew into dard. (Infrequent.)

(*d*) No stipulary eyes developed. Eye in axil of one of the basal leaves grew into thin wood shoot. (Frequent.)

(*e*) No stipulary eyes developed. No eye in axil developed. Spur died. (Very common.)

Thus only two out of the five possibilities, (*a*) and (*c*), gave satisfactory results and these were of infrequent occurrence. Generally no bud at all developed and the spur died in consequence. The thin wood shoot obtained in many cases, especially in a wet season, is very difficult to deal with if there is no developing dard behind it, because its own basal buds are all so weak as to be practically non-existent.

These failures may be ascribed to faulty directions of the book. The " basal cluster " idea is a much better one, though even this sometimes requires modification. According to Lorette when a shoot is pencil thickness and beginning to lignify at the base and about 10-12 inches long, it may be cut to the " basal cluster " At Long Ashton, however, shoots of the right length, thickness and woodiness at the base very frequently have no basal cluster or a very poorly defined one. In fact most of the shoots produced here are of that character. Lorette gives no guide as to what to do in these cases. Probably under his conditions he had none or very few. There is no cluster to cut to, and if one cuts them to one centimetre as advised the spur usually dies. Much more satisfactory results can be obtained if the position of the basal leaves is taken as the criterion of where to cut, the time for cutting the majority of shoots being fixed for the end of June for pears and about July 20th, for apples. Then in the few cases where a basal cluster is well-developed a cut may be made to this point. Even then some failures resulted. Where the basal cluster is poorly developed or absent the best method is to cut to two visible eyes. If cut to one only, this bud develops into a thin wood shoot and no buds start behind so that nothing is accomplished. In the case of the cut to two buds, however, the top develops into a thin wood shoot and the bottom one into an incipient dard. In the Long Ashton climate two buds very seldom grow out, so Lorette's method of cutting to three (as in the case of weak wood shoots) has to be modified to two. Occasionally, however, when the wood shoot is especially strong or in a favourable position (just below an extension prune), or if the variety is a vigorous one, two buds will grow out and the cut must be made to three eyes. This is, of course, a matter of experience and judgment. In very wet summers there is frequently no visible effect on the second bud and summer pruning is practically then a failure.

The rule for cutting therefore works out thus. At the proper time cut every wood shoot that is not a brindille, no matter what its

length is, provided it is at the right stage of woodiness. Cut to the basal cluster if well developed otherwise to two visible eyes or exceptionally to three.

Second generation shoots were produced as the result of the hard cutting in the first two years' experiment. These were always thin and spindly. If cut again a month after the first cut, as Lorette directs, the spur usually died. When the cut to two eyes was substituted, the thin shoot produced did not matter as there was a developing dard behind; and it could be cut away at a later date. When this was done at the July–August prune no effect could be observed on the developing dard below. It was not stimulated as far as the eye could see. The operation, therefore, seemed pointless for Long Ashton conditions, and as a matter of fact it was soon found that July–August prunings were dangerous owing to the liability to canker infection. This liability seems to begin in July and greatly increases in August. For this reason alone prunings in August for the apple should be avoided here.

No third generation shoots were ever produced at Long Ashton. Altogether Lorette seems to have obtained far greater effects from his second July–August pruning than can be got here.

3.—*Pruning of Wood Shoots on Developing Spurs.*

Here Lorette's direction seems to be undoubtedly correct. If as usually happens there are dards or developing flower buds behind the wood shoot these must not be forced out into growth by too short a prune. At the same time they must be further stimulated. For this reason a sap-drawer with one good eye is left. If more than one sap-drawer were left, or one sap-drawer with two good eyes, there would be a danger of the dards remaining undeveloped.

His method of treating grown out dards is also obviously correct, though sometimes at Long Ashton in wet seasons the treatment results in no buds developing in the basal cluster and a dead spur being produced.

4.—*The Treatment of Brindilles or Twiggy Shoots.*

Here one comes to what is perhaps the least instructive part of Lorette's teaching. He himself seems rather vague in his opinions and gives various methods of treatment in different parts of his book. At one point he says that they are unsuitable for cutting. At a second he advises cutting to three leaves, presumably eyed ones, at the end of June, and at a third his advice is that they should be bent downwards by a small weight and an oblique incomplete incision should be made with a knife between the third and fourth leaves. This process is supposed to cause the back buds to break. Where possible, as Lorette says, they should be left untouched in the case

of vigorous trees in order to fruit, but it is precisely in such cases that they are liable to end the season with a wood bud terminal. Such brindilles will not fruit and only crowd the tree if left. Further, in any case it is difficult at the time of the first prune to estimate whether a brindille will end the season crowned with a flower bud or not. Something therefore has to be done. The most satisfactory operation seems to be to cut to two visible eyes as in the case of most wood shoots without a basal cluster. Owing to their nature usually not more than two buds break, the hinder one becoming a dard. If, on the other hand, they are formed of more than one year's wood and have dards already behind them, the cut to the basal leaf at the end of June, for pears, gives the best result. These dards rarely grow out. Certain varieties of apples, such as Worcester Pearmain, Allington Pippin and Lord Hindlip, produce a large number of brindilles. In the drier climates of the Midlands and East of England these are best left if not more than six inches in length at the pruning time. They usually bear fruit the following year, and the bending down due to the weight of the fruit usually causes one or two buds behind to develop into dards. They can then be shortened. In the wet Long Ashton climate, however, this by no means always happens and for this reason only short brindilles should be left untouched. In all climates if brindilles are more than six inches at the time of pruning they are best treated, especially if obviously still growing in length, as the chances are that such shoots will not possess a flower terminal bud at the end of the season.

These brindilles are produced in several ways. Usually they are the result of a late start of comparatively strong wood buds. Thus a weak dard may start in early summer instead of spring, either through too hard pruning or through a sudden spell of wet weather, especially if this succeeds a period of drought. They are also produced in a modified shorter form from the bourse eyes in tip-bearing varieties like Worcester Pearmain, Allington Pippin and Lord Hindlip. These eyes start late in the season, about June, (they are not formed of course till after the flower has fallen), but stop growth comparatively early, bearing again flowers at their ends.

5.—*Treatment of Bourses.*

The treatment of wood shoots from bourses is also probably correct, but the practice is not always easy. Thus, when fruit is there it is often difficult to see if dards are present, at least reasonably quickly. If a developing flower bud occurs behind on the bourse a cut to the basal leaves of the wood shoot may force it out, though generally if fruit is forming this will not happen.

When no fruit has set it is easier, though not easy, to see what one is doing; and in that case, unless one is sure, perhaps a cut to two eyes is safer. On the other hand, when fruit is present and it is desired to cut a wood shoot of a bourse closely, it is sometimes impossible to do it owing to the bulge of the fruit. In that case one prunes as closely as possible.

6.—*September Clearing.*

According to Lorette all stubs of treated shoots are completely removed at the Aug.-Sept. prune, leaving only flower buds, dards and brindilles beside, of course, wood shoots which are extension growths of already formed leaders.

At Long Ashton no effect could be seen to follow from this operation and there appears to be no reason why this should not be done in winter if more convenient.

Conclusions.

Summarised therefore one may make the following criticism on Lorette's directions for the Long Ashton conditions.

(*a*) Pruning hard to obtain stipulary eyes for flower formation is very unsatisfactory.

(*b*) Pruning to the basal cluster where present is far better, but results in occasional failures.

(*c*) Where no basal cluster exists a prune to two visible eyes, not three, should be made.

(*d*) The time of year, the state of lignification at the base and the presence or absence of basal cluster should be used for criteria rather than the length or thickness of the shoot.

(*e*) Brindilles should be cut to two eyes where they cannot be safely left, not to three. The bending down method is hopeless except for a garden.

(*f*) Shoots from bourses should be cut as close as possible, if carrying fruit; if not, treatment should be according to whether large dards are present or not.

Section III.—The System in Relation to Loeb's Hypothesis of Growth Inhibition.

It must be at once admitted that Lorette's system is a brilliant piece of empiricism. Like all empiricisms it does not pretend to explain, and like all empiricisms it only works under conditions similar to the original ones. Nevertheless his methods are of the greatest interest and may prove most valuable in the long run to commercial growers.

His main ideas as regards flower production appear to be two. One is pruning only when "the sap is in motion." This idea is not, of course, out of the ordinary as regards spur pruning, but it would appear to be so when applied to the leaders. And yet, perhaps, it is not so novel as appears at first sight, since no effect of pruning is ever produced unless and until vegetative growth follows. Thus a winter or dormant season prune does not have its effect until growth begins in spring, and a summer prune has no effect if the tree is stunted or its growth completely pulled up by drought. The sole difference, therefore, between those and Lorette's April-May extension growth prune is that the effect of the latter takes place a week or two later than that of a winter prune. In practice there is no difference in the effect produced. Indeed this pruning must be put off till towards the end of May to produce an effect on the basal buds.

Thus, if one prunes an extension shoot at this time and the cut be made behind those apical buds which are still actively growing to a bud that has settled down nearly or completely to the dard condition, it may be shown by direct measurement that the basal buds are stimulated. The growth in length thus produced is not large but it is distinct. After the new terminal begins to grow out further measurable stimulation of the basal buds ceases.

Again, a similar basal stimulation may be obtained by cutting an extension shoot in April to bare wood. Certain varieties at Long Ashton, like Beauty of Bath, produce a considerable amount of bare wood, especially in young specimens. If the prune be made behind all growing buds to a dormant one, this one and several more behind will be forced out. Like the first case, however, the duration of growth of these basal buds is short and is limited to the time during which the new terminal bud is growing slowly. As soon as it attains rapid growth in length further growth in length of the basal bud ceases.

The difference in result between Lorette's April-May extension prune and the two cases just cited can be easily explained by Loeb's hypothesis of growth inhibition and, so far as the authors are aware, by no other. This hypothesis postulates that the foliage of a growing plant produces some substance which, being conveyed backwards through the stem, has a toxic and inhibiting effect on buds situated more basally. That is to say, a substance is produced which travels probably chiefly, if not entirely, through the phloem tissues and tends to prevent buds situated more basally from growing out. This hypothetical substance has not yet been isolated and may indeed be incapable of isolation, but the assumption of its existence explains so many facts, and fits in so remarkably well with many hitherto unexplained phenomena of plant activity, that one is justified in using the hypothesis until disproved. Applying

it, therefore, as a working hypothesis to the three cases cited, the following conclusions are arrived at.

Lorette's April-May prune is to an active bud which is elaborating toxin and therefore there is a check to the further development of any basal buds. A prune to a closed bud at the end of May, or to bare wood in April, is to an inactive bud and therefore for the time no toxin, or a nominal quantity only, is being passed backwards. Thus the basal buds or the dormant buds have a chance of development until they are inhibited by toxin produced by the growth of new leaders or of buds more apical to them.

Lorette's second main idea appears to be the use of dormant basal eyes for development of flowers. This practice has one great advantage in that the flowers and fruit are carried close to the main supporting stems. It also has a second advantage, this being that these truncated clusters take a long time to develop fresh active growing points. During that time it would appear to follow that there may be more available food for buds developing in the right direction and certainly less toxin in the bottom portion of the tree. Whether this reasoning is correct or not, it is an undoubted fact that the basal cluster cutting tends to keep the lower portions of the tree better furnished and increases the size of the fruit.

He maintains that both stipulary and basal cluster eyes are more suitable for production of flower buds than eyes higher up a wood shoot. Of that he does not give any evidence, nor does there appear to be any. Nevertheless the other advantages accruing are quite enough to justify his practice. To one accustomed to the usual method of summer pruning in August, where the cut is made to four or five eyes for the future spurs, Lorette's system seems both too early and too hard. The August prune, however, is generally useless for flower production. If the cut is made to five buds, only two buds at the most are apparently influenced by the end of the growing season. The apical bud of the pruned shoot may make an outgrowth and the second bud may be plumped up. Nothing further visibly happens, and both these " influenced " buds are removed by the winter prune, so that the result of the summer pruning is nil. The Lorette way is quite different. The summer prune is much earlier, but its earliness is balanced by the weakness of the buds to which the prune is made. The buds that have been " influenced " are not removed by winter pruning and the flower buds are obtained close to the supporting branches.

One may apply Loeb's hypothesis still further, and show why Lorette's methods are usually satisfactory, and why they partially fail at Long Ashton. Before doing this, however, in detail it is necessary to consider the hypothesis still further in its bearing on tree growth.

According to the definition of the hypothesis the inhibiting action depends on the amount of active growth that is being made. If this is so, the general growth activity of the tree should serve as a measure of its amount, and its activity may be estimated by the growth in length of the leaders. Weekly measurements of leader growth were made during one season at Long Ashton for three varieties of pears and five varieties of apples. For each variety two leaders were measured on each of five trees every week during the growing season. Each variety thus had ten measured shoots distributed over five specimens. Averaging up the measurements for all the pears, it was found that there was a sharp rise of weekly leader growth to a maximum, which was reached on the 22nd of May. This figure was maintained almost at the same level till June 6th, after which there was a moderate descent to June 26th, and a further much more gradual descent to zero by July 31st. For the apples the rise to the maximum was slightly less steep and its attainment was three weeks later, namely, on June 12th. From here there was a moderate descent in intensity to June 26th, after which it remained practically the same to July 17th, and then fell gradually to zero on August 14th. Admittedly these results only refer to one year, but there is no reason to suppose that they would be seriously different in other years. Indeed less complete measurements of a previous year, which those just quoted were designed to supplement, all tended in the same direction. The results show that leader activity and, therefore, presumably Loeb effect for pears is three weeks in advance of that for apples. They further show that the intensity attains a maximum in the early part of the season, ranging about the end of May for pears and the middle of June for apples. After the maximum in both pears and apples there is a moderate decline for about two weeks and a further gradual decline for about six weeks.

It is now possible to look at Lorette's methods from the point of view of the Loeb hypothesis. It is, of course, realized that the growth-inhabiting substance may be, and probably is, only one of the acting factors. There may be, and probably are, other factors, prominent amongst which is no doubt the distribution of available food supplies.

The simplest case in the Lorette treatment for production of flower buds is that of the wood shoots of one year's growth only. From their nature these can only be found arising from the supporting branches of last year's growth. They are, therefore, always to be found towards the top of the tree and they consist of those shoots not destined to act as extension shoots of supporting branches already in being. Lorette directs that those with good basal clusters shall be cut to the dormant eyes of these clusters when the shoot has attained the right degree of lignification at the base and

the right length and thickness. These conditions are found round about the end of June, and the third week in July, for pears and apples respectively. At these times, as already shown, the general Loeb effect has passed its maximum and is decreasing in intensity. The basal dormant buds are, however, subjected to the Loeb effect from two directions. Firstly and mainly, they are influenced by toxins descending from the apical bud of their own shoot and, secondly, by those descending from the rest of the tree above them. After the prune to the basal cluster the main supply of toxin is cut off, but they are still presumably under the influence of the second supply. This, therefore, will determine the amount of the Loeb effect. As has been shown, however, in the second article of this series,* there is a second factor, the bud factor, that comes into play to determine whether any given bud will or will not grow out. It is uncertain exactly what this factor means, but there is an indication that it has to do with vascular supply, though the availability of food must not be ruled out. It seems to be determined largely by the previous history of the shoot. Thus a shoot commencing to grow out in the height of the growing season possesses extremely weak buds at the base. A quick apical growth means a large Loeb effect, and this would thus explain why these basal buds are especially weak. The position therefore is this. After the basal cut has been made the development of the dormant basal buds will depend (*a*) on the intensity of the general Loeb effect descending the tree and (*b*) on the strength of the dormant basal buds. These, though dormant and invisible to the naked eye, nevertheless actually exist and may be spoken of as either stronger or weaker. It may be supposed therefore that in the drier conditions, like those of the Midlands and East of England, the dormant buds will be relatively strong, while in the wetter, as at Long Ashton and the South West of England, they will be relatively weak. In both cases the toxins descending the tree should be less than for shoots situated lower down in the tree, since there is less producing tissue above them, though even here in the wetter climates it would be greater than in the drier. The inhibiting factor for these basal buds is thus relatively small and there is in consequence a tendency for them to grow out into wood shoots. These shoots are the secondary ones of Lorette and become apparently thick enough for him to apply the same process again in a month's time. At Long Ashton, owing to the quicker growth and bigger Loeb effect produced, the shoots are thin and spindly and altogether unfit for a second treatment.

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* Factors Governing Fruit-bud Formation." II. " The Normal Annual Growth of the Apple and Pear."—*Annual Report Long Ashton Research Station.* 1919.

Shoots that are not of pencil thickness, but are otherwise suitable for cutting, Lorette cuts to three eyes. Such shoots, as indicated by their lack of thickness, are generally of quick growth, having been subjected to a big local Loeb effect, with the consequence of especially weak dormant basal eyes. For this reason they cannot be cut to the basal leaves and Lorette's exceptional cases become the general case for the wetter climates like Long Ashton. Even here, however, a further modification has to be made owing to the high local Loeb effect, and the cut has to be made to two eyes (usually) and not three, since the effect of the prune only extends back (usually) to two eyes and not to three.

For wood shoots arising from wood treated last year, *i.e.*, from what are really incipient spurs, Lorette advises cutting to the basal cluster if no dards are found behind it or to one eye if developing dards are present. If more than one wood shoot is present, all are removed except the weaker, which is cut to one eye. These practices are again clearly explained by the Loeb effect. Where no dard is present, but only a wood bud, a considerable stimulation is needed for transforming it into a dard. By cutting to the basal cluster the local Loeb effect is thereby removed. The practice is correct for dry or wet climates, since it is the maximum cut that is possible and it does not matter if the basal cluster fails to develop eyes, there being a well formed wood bud behind which can be influenced. Where dards are present behind, less stimulation is required and so one eye is left in front. This is a weak one and takes some time to grow out, though not so long as the basal eyes; but during this time sufficient stimulation is given to transform the dards into flower buds. If the prune were made to the basal cluster, dards would be caused to grow out owing to the removal of the Loeb effect for too long a time.

The brindilles are undoubtedly the most difficult of all the growths recognized by Lorette to treat successfully. They are, perhaps, best regarded as merely a specialised form of wood shoot. They are generally formed from weak buds that have made an extra quick growth owing to a late start bringing them into the height of the growing season. They have on that account the usual ill-developed basal buds and therefore as shown above cannot be cut here. Regarded thus, they simply fall into the class of shoots that have been under a specially high Loeb effect, somewhat similar to, though more extreme than, the ordinary wood shoots formed in wet climates. Their treatment therefore is the same: namely, a cut to two visible eyes. Lorette's bending and incision treatment, though obviously impossible on a commercial scale, is interesting, as both processes cut off part of, but not all, the local Loeb effect. If all is cut off, as in pruning to two eyes, though there is a time when no Loeb effect is descending on the basal buds, this time is short owing

to the pruned eye growing out and thus remaking a considerable quantity. If bending and incision are practised the Loeb effect is lessened, but the lessening lasts longer than the complete removal; so no bud grows out and many are plumped up. One gets therefore several buds going into dard form instead of one.

The bourse may be looked upon as a wood shoot which may or may not be bearing a fruit. It also frequently has developing dards on it. If it has, Lorette says "cut to two eyes." The fact that he advises two and not one, as in the case of a wood shoot from a spur, may easily be due to the fact that shoots from a bourse, being necessarily late growths, are especially poorly formed at the base. Therefore one eye would not give enough Loeb effect to keep dards from growing out, especially if no fruit be forming. Where no dards are present, the bourse shoots may be cut to the base just as in the case of incipient spurs.

In September Lorette cuts away all stubs or previous prunings. At Long Ashton no definite result of September pruning has ever be seen. Whether or not there is any advantage in the September prune over a similar prune in winter is doubtful. At this time the tree has ceased growing and, except that it has not dropped its leaves, has practically attained the winter condition.

The Loeb hypothesis thus serves to explain Lorette's results and also his failures when applied to wetter climates. The system may indeed become a complete failure in extra wet summers at Long Ashton. In these cases the Loeb effect is so high that only one bud is influenced as the result of a prune, viz., the apical one left, which grows out into spindly wood. The second and remaining buds are unaffected and the result of the pruning is nil. The hypothesis also indicates the direction of control. It is clear that the Loeb effect must be weakened if possible. This may be done by root pruning, which is an extremely clumsy method, by using a more dwarfing stock which may have mechanical disadvantages, or, perhaps more easily than any other method, by main trunk or main branch ringing. This subject is treated from the practical point of view in the last section and the reader is referred to it for details.

It has been shown that Lorette's first summer pruning is fully justified, both on theoretical and practical grounds, if certain necessary variations are made when occasion required. His subsequent prunings, however, are of more doubtful merit. Certainly there is a strong tendency for them to be less effective. The position is further complicated by the fact that, for apples, after the first July pruning there is rather a strong probability of canker infection. For these reasons it has been found to be a better practice at Long Ashton to omit any second or third summer prune and to apply a second one in winter. A further strong argument for this accrues when the whole practice of pruning is considered from a

commercial point of view. It may be safely taken as self evident that no grower would be able to afford the time to do more than one summer prune. Many will no doubt deny that they have time even for this. Whether it will pay or not to put extra labour on for a single summer pruning will, however, depend on the results that can be obtained. A few growers have already begun to put some of Lorette's methods into practice, so that they at any rate regard the experiment as worth making. There, indeed, seems very little doubt from the results already obtained at Long Ashton that, if his methods can be rendered reasonably simple and within the understanding of ordinary labour, they should be a source of considerable profit to growers.

Section IV. A Suggested Scheme for Commercial Practice.

Lorette's complete system does not appear to be applicable to commercial practice owing to as many as four prunings being necessary, one extension prune in spring and three subsequent prunings in summer and autumn. Only one summer pruning could probably be done commercially, but a satisfactory scheme for flower production can be formed if solutions can be found to the following points.

(1) Only one operation to be performed in summer, but a second one admissible in winter, when there is far more time.

(2) Some means of forcing the breaking of dormant buds by other means than pruning.

(3) Directions for summer work to be so simplified that ordinary labour will be capable of carrying them out after a little practice. (When the owner or foreman does the work the directions may be more complicated.)

(4) Some means of controlling excessive Loeb effect when circumstances nullify pruning results.

(1) *and* (2). *The Winter Prune and Knife-Edge Ringing.*

From what has been already said in previous sections it is clear that the prune coming about July 21st for apples is the one that has the greatest effect. This therefore is the time when summer pruning should be done. After that the trees need not be touched till the dormant winter season.

At this period pruning has two objects.

Firstly, the tree must make further extension growths, if not already of full size. This is largely a question of training and cannot be discussed here. There are, however, one or two points that can be touched on. The leader is cut generally at such a point

as will, in the opinion of the pruner, cause a satisfactory break of basal buds. This, however, is not necessary if, as in point 2, some other method is known for forcing dormant buds. Suitable ringing will have this effect. The method then becomes as follows. Cut the leader in winter to any eye desired. When the spring comes and the buds begin to show green it is possible to see how many basal buds are going to remain dormant on the pruned leader. When this is seen, make a knife-edge ring just below the last bud that shows green. A knife-edge ring is a ring made with the edge of a knife without removing any tissue. The knife, which should be a small one for convenience, is held by the handle between the last members of the thumb and fingers, the thumb being on one side and the fingers on the other. The shoot is held in the left hand just. below the place to be treated. The blade of the knife is then brought round the far side of the shoot and is made to approach as nearly as possible to the body of the operator, the wrist being bent inwards as far as possible. Then the cut is started with moderate pressure and the knife-edge drawn round the wood, till by the reverse movement of the wrist and with a finger and thumb grip, it meets the cut already begun. In this way a complete knife-edge ring can be made in one movement and in one second.

One knife-edge ring put in at this season of the year will generally cause from three to eight buds to break. Most of these breaks will go into dards naturally. If the blank space be too long a second or third ring must be made. In most cases one ring is sufficient. No explicit directions can be given as to the number needed, as it will depend on the variety treated and other conditions. As a general guide, however, it may be stated that the greater tendency a variety has to form bare wood, the less effect a single ring will have and the more rings must be made. In no case, when operation on small branches, should a ring be made in which tissue is removed.

The second object of winter pruning is to change otherwise useless wood buds into flower buds. It must be remembered that the effect of the prune will be confined to early spring, when the Loeb effect is small. For this reason usually three buds are influenced behind the pruning cut. This is no doubt the reason behind the well-known continental three-bud spurring system, and so it may be recommended as a general practice. All shoots that are not leaders, or do not already bear flower buds or dards are treated in this way, roughly, that is to say, all wood shoots that require shortening. The method is to count three good buds from the base and cut above the third. A good bud is one, which in the opinion of the pruner, will develop. This is a matter of experience and may result in leaving anything from two to five inches of wood. If the wood growth consists of more than one year's growth

from the supporting branch, the count is made from the older wood upwards. If there are dards here, each counts as one. If this process were not adopted and a prune to three eyes on the single year wood were made, the dards would be starved.

There are certain exceptions to be made in this method. Firstly, if a flower bud is present on the older wood the cut is made just above it, whatever its position, thus shortening the spur. If several are present the continental method advises that only one should be left. This is probably erroneous, since two or three may be left with advantage. Lorette leaves far more, but it must be remembered that he restricts his total bearing surface far more than most growers do. For those who wish to exercise greater skill an exception to the exception may be made. Thus, where there is one flower bud behind the wood shoot, but this wood shoot is in a strong position just behind a previous winter's prune, the cut should not be made to the flower bud, but to one wood bud in front. The object of this is to prevent the two buds on the future bourse from growing out.

In certain varieties of apples, like Worcester Pearmain, which are tip bearers, there is a large proportion of brindilles. If crowned with a flower bud these should be left where they do not crowd the bush too much. This rule applies more especially to young specimens. If too long, or on already spurred bushes, they may be pruned to three eyes as usual. Older spurs bearing several dards and flower buds should be depleted of all wood shoots and may, if too long, be even shortened themselves.

The directions for winter pruning can now be summarised thus :—

(*a*) Cut leaders to bud desired and put in knife-edge rings below last bud to develop in spring.

(*b*) Spur wood growths to three good buds.

(*c*) Leave brindilles where possible to fruit, if not cut to three buds.

(*d*) Where possible on a compound wood shoot cut right back to a flower bud if present. (With exception as in text). Where more than one flower bud is present on a spur two or three may safely be left, but not generally more.

(*d*) Remove all wood shoots completely from the older spurs which are already bearing dards and flower buds. Where the spurs are long shorten them somewhat.

(3) *The Summer Prune.*

For growers and foremen who are capable of understanding Lorette's directions the most satisfactory course is to follow them. His directions, as set out in the first section, are suitable almost

certainly for the drier parts of England, including the Midlands and the East. Growers in the South-West should follow the variations mentioned in the survey of Lorette's methods. The chief differences between the two regions will be the poorer development of basal clusters in the wet and the advisability of cutting to two visible eyes instead of three.

Tabulating the concise directions of the Lorette summer prune (about June 30th, for Pears and about July 21st for apples), and the variations for the wetter climate, the following is obtained :—

Treatment of.	Drier Climate.	Wetter Climate.
"Bourgeon" or Wood Shoot.		
(*a*) If basal cluster present.	Cut to basal cluster.	Cut to basal cluster.
(*b*) If basal cluster absent.	Cut to three visible eyes.	Cut to two visible eyes.
"Lambourde" and Spur.		
(*c*) No dards present at base.	Wood shoots cut to basal cluster.	Wood shoots cut to basal cluster.
(*d*) Dards present at base.	One wood shoot left, which is cut to one visible eye.	One wood shoot left, which is cut to one visible eye.
(*e*) Grown out dard.	Cut to basal cluster.	Cut to basal cluster, if strong. If weak, to two eyes.
(*f*) "Brindille" or Twiggy shoot.	Cut to three eyes or leave to flower.	Cut to two eyes or leave to flower.
Shoots from "bourse or knob."		
(*g*) If no dards present.	Cut to basal leaf.	Cut to basal leaf.
(*h*) If dards present.	Cut to two visible eyes.	Cut to one visible eye.

This table should suffice for growers who can do the pruning themselves or entrust it to their foremen. Where, however, operations are on too large a scale for this and ordinary labour has to be employed, some simplification would appear to be necessary. The results will, of course, not be so good.

The simplest modification would be to have all varieties of wood shoots cut back to about half an inch. This would suit cases *a*, *c*, *e*, *g*. When dards were present they could in most cases be forced out. The next modification would be to distinguish between shoots with good basal clusters and with bad ones or none at all. This treatment would suit cases *a*, *b*, *c*, *e*, *f*, *g*. The next stage would be the recognition of dards behind a wood shoot and would include the full scheme.

Which scheme should be attempted must be left to the discretion of the grower.

The combined winter and summer pruning (modified Lorette), has been on trial for some years at Long Ashton and has given satisfactory results. The system may therefore confidently be recommended to growers as one of great possibilities.

(4)

Cases frequently occur in practice where for some reason the pruning methods above described are more or less ineffective. These cases are always produced when growth activity and, therefore, the Loeb effect is excessive. When this is so, a prune only influences the bud pruned to and not any buds behind it, so that the result of a cut is simply a new wood shoot and there is no tendency to transform wood buds behind into dards.

The commonest instance is afforded by a wrong root-stock. Thus, with the exception of specially precocious varieties, a free stock is always unsatisfactory for bush form. There is a great tendency to form spindly shoots and there is the greatest reluctance for buds to form flowers. This tendency is still further accentuated if the scion is a strong one, like Newton Wonder or Bramley's Seedling.

Heavy manuring in certain circumstances may also produce the same results, though these conditions are generally only found in gardens.

Young stages of strong growing varieties, like Newton, Bramley and Beauty of Bath, even when on a Paradise stock, also show the same tendency. In this case, however, the stage is generally a temporacy one and, as the tree gets older, it gradually disappears. Nevertheless it is sometimes desirable to shorten this period by artificial means. This can be done by ringing the main trunk or main branches.

In extreme cases, such as old bushes of strong growing varieties of free stocks, a ring of half an inch may be completely removed from the main stem in spring, or a ring of one quarter of an inch from the base of the main branches. These sizes should in no case be exceeded at the first time of application. The operation should be preceded or accompanied by a thinning out of the leaders where necessary, but these should not be cut back. This practice is far preferable to root pruning and has a very similar effect. Such rings will normally heal over by the end of the season. As a precaution against infection by wound-parasites an antiseptic dressing should be applied to the cut surfaces.

Where a tree is suffering from over-manuring—and this in commercial plantations will be very rare—a main-stem ring of one-quarter of an inch, or branch ringings of one-eighth, should be tried. Branch ringings afford the means of weakening any particular branch.

In the third case, where it is desired to accelerate the flowering of such reluctant flowerers as Bramley or Blenheim Orange, ringing may also be employed, but considerable care must be exercised. It is, of course, easy to overdo the process and stunt the tree, but with care a satisfactory result may be obtained. If the bush is not more than five years old and shows no sign of flowering, the main stem should be ringed about one-eighth of an inch broad. If this

heals over very quickly and flower buds still fail to form in sufficient numbers when pruned as above, the process should be repeated the following spring. As a rule, however, the check to the tree will be sufficient to bring it under pruning control.

In older bushes of ten years or more the size of the main stem ring may be increased to one-quarter of an inch, or one-eighth inch rings may be put on branches, if preferred.

By means of ringing, therefore, refractory cases may be easily handled, and there is no reason to doubt that with the pruning methods described, combined with stem ringing where necessary, any apple or pear may be brought into flower, always provided that the other needs of the tree, such as manuring, cultivation and light are properly attended to.

ROOT DEVELOPMENT IN NEWLY PLANTED TREES.

By B. T. P. Barker.

The results described in this article are the earliest arising from a series of investigations which have been begun with the object of elucidating the part played by the root-system of a fruit tree in determining its course of growth, general health, fertility and quality of fruit. The studies on the morphological nature of free and Paradise apple rootstocks, which have been in progress since 1913 at Long Ashton and East Malling, and those at the latter Station on pear quince and plum stocks may be regarded as supplying essential preliminary data required before the main problems of root action can be satisfactorily tackled. The way has thus been cleared for a start on some of the lines of attack. As opportunity arises the investigations will be extended to other phases of the subject.

One of the first points to be ascertained is the natural course of development of the root-system of a tree. Fruit trees as ordinarily grown, not being plants raised from seed and left standing undisturbed in the ground on the spot where the seed germinated and the seedling developed, have sooner or later to be transplanted from nursery quarters to their permanent positions in field or garden. The behaviour of the root-system following transplantation is, therefore, a critical factor in the life-history of the tree, and it may well be imagined that the future fate of the latter is practically determined by the manner and rate of recovery of the root-system after the shift. For this point it is obviously immaterial whether the tree is on its own roots or worked on another rootstock ; the shock of transplantation is inevitable in either case and the recovery of the root-system all-important.

The commonest case presented in commercial fruit growing in this country—leaving out of account entirely the case of soft fruits, which will be dealt with on a later occasion—is that of trees budded or grafted on a distinct rootstock. There are instances, such as that of the Pershore plum, where the trees are commonly grown on their own roots; but outside the stone fruit group examples of this are unusual. The case of the apple worked on some form of Paradise stock is doubtless the most familiar of all and, on account of its general interest, it has been selected for the first investigations.

Plan of Experiments.

The programme of the work, briefly stated, has been arranged as follows. A plantation of apple trees, one to three years old from the graft, was established in the late winter of 1920, the trees being grouped in two sets. The one set consists of trees planted as permanent in rows 15 feet apart with individual trees in each row at intervals of 15 feet. The other set is planted in temporary quarters in rows alternating with the preceding, the distance between the temporary and permanent rows being 7½ feet only. In the temporary rows the trees are set at intervals of 15 feet as in the case of the others. The temporary trees are to provide material for direct observation of root growth. There are 150 of these in all, 30 to be lifted and examined at the end of the first year's growth, 30 others at the end of the second year and so on, until by the end of five years all will have been removed. By this system it is expected that the different annual stages in the development of the root-system can be followed in detail without occasion to disturb in any way the permanent trees. These, of which there are 150 also, are to serve to indicate the nature of the correlation between the growth of the root and that of the branch system of the tree. Shoot growth in relation to root growth will thus be followed stage by stage.

An investigation of this kind involves uniformity of treatment, both of root and shoot, of individual trees at the time of planting, otherwise the results may not be strictly comparable; and it was when a decision as to the standard form of treatment to adopt was sought that a real difficulty was met. There is in fact no uniform system universally adopted either as regards root or shoot treatment at the time of planting. Some growers prune the roots carefully; others do not. Some prune the leading shoots; others leave them unpruned till the end of the first year's growth. It became evident, therefore, that in order to obtain results to cover the various classes of practice it would be necessary to test the effect of a variety of root and shoot treatments. Before describing those finally decided upon, a brief digression is desirable to make the reasons for the decision clear.

The most complete investigation on the planting of fruit trees which has yet been made in this country, is that by the late Mr. Spencer Pickering at the Woburn Experimental Fruit Farm. Some thousands of fruit trees of all kinds were planted at various places and in various ways under his direction. Although all the results were not of the same general order, the experiments as a whole led him to two decided and definite conclusions, viz., (*a*) that care of the existing root-system at the time of planting is unnecessary, since the fine fibrous roots apparently die off or at any rate cease to function and have to be replaced by a new set formed from the older parts of the roots, and (*b*) that the main factor in encouraging the

development of a strong new root-system and, thereby, the ultimate growth of the tree is excessively vigorous ramming of the roots in the soil when planting. Of the many results of the Woburn work which have, when first announced, aroused controversy, there were none which called forth such widespread dissent as these. They conflicted entirely with accepted practice and, except in so far as ramming may be synonymous with firm planting, have been almost universally rejected. Pickering's results, however, never appear to have been satisfactorily explained by his critics, whatever view may be taken as to the validity of his conclusions: and the scientific observer can hardly resist the impression that the position is still obscure because the complete story has not yet been fully revealed.

From this it follows that any series of experiments on root treatment in relation to subsequent growth must be incomplete unless an attempt to clear up these points is included. Hence the ultimate form of the investigations under consideration here. Instead of a single form of root treatment being followed for all the trees at the time of planting, five different methods were used, equal numbers of trees being taken for each. The first group had the roots treated according to the prevalent idea as to best practice, viz., all fibrous roots carefully retained, broken ends of roots of any size properly pruned, all roots spread out evenly in the hole prepared for planting, and care being taken when filling in the soil to avoid unnecessary damage to the roots and to leave the tree firmly fixed in the soil, although not rammed in an extreme way. The second group was treated similarly, except that in planting the roots were rammed according to Pickering s method. The third group was constituted of trees which had all the fine fibrous roots deliberately removed before planting, the coarser main roots and branches being alone retained. Firm planting without excessive ramming was adopted in this case, as in the first and the two following. The fourth group was as the third, but for a certain amount of deliberate root mutilation. The coarser roots were slashed with longitudinal cuts made with a pruning knife and penetrating through the cortical tissues to the vascular cylinder, the object being to test Pickering's hypothesis that points of injury serve as centres of new root formation. In the fifth group all branch roots, large and small, were removed, leaving only the carrot-like central stump some six inches or so long. This corresponded practically to the Stringfellow method which was advocated a few years ago in the United States, but never appears to have established itself very firmly there.

Each of these five groups was in turn sub-divided into two for differential shoot treatment. One half of the trees in each were pruned at the time of planting, and the remaining half left unpruned,

the first pruning in their case to be given before the start of the 1921 growing season.

Actually, therefore, the trees in the experiment were divided into ten sets according to treatment, the details of which may be summarised as follows :—

Set I.—Root fibres retained : tree unrammed : branches pruned.
Set II.—Root fibres retained : tree unrammed : branches unpruned.
Set III.—Root fibres retained : tree rammed : branches pruned.
Set IV.—Root fibres retained : tree rammed : branches unpruned.
Set V.—Root fibres removed : tree unrammed : branches pruned.
Set VI.—Root fibres removed : tree unrammed : branches unpruned.
Set VII.—Root fibres removed and roots cut : tree unrammed : branches pruned.
Set VIII.—Root fibres removed and roots cut : tree unrammed: branches unpruned.
Set IX.—Root reduced to short stump : tree unrammed : branches pruned.
Set X.—Root reduced to short stump : tree unrammed : branches unpruned.

Concurrently with these trials in the open ground, two somewhat similar trials were conducted with smaller numbers of trees in pots, one group being planted in sand and the other grown in water. The object was partly to facilitate observation of the behaviour of the root-system during the growing season, and partly to ascertain if the nature of the medium in which the roots are grown has any material influence on the general course of new root development. That the character and size of the new roots would differ was, of course, anticipated ; but whether a difference of origin and distribution would be shown was unknown.

Both in the sand and water cultures, which were kept in the open air, the roots were treated as in the open ground trials with the exception that the ramming method was perforce omitted. It being necessary to limit numbers no attempt was made to test the effect of shoot pruning and non-pruning. All the trees in the pots were therefore pruned.

During the growing season the trees in sand were fed regularly by watering with a dilute solution of potassium nitrate and potassium phosphate. In the case of the water cultures fresh tap water alone, changed daily, was used in the majority of cases, but a

similar nutrient solution to that used for the sand cultures was also tried for at least one tree under each type of root treatment.

The results of the first season's growth of the root-systems in the three different media—soil, sand, and water—have been compared, and the facts which have been observed are so positive in character that it seems unnecessary to withhold publication until the full course of the investigation has been run.

Results.

Root formation in open ground.—Dealing first with the phenomena shown by the open-ground trees, the extent of new shoot growth shown by the trees under the respective forms of treatment at no time during the growing season indicated to the eye any pronounced and uniform gain in favour of any individual method. At the time of writing the actual growth measurements have not been completed, and whether or not they will reveal any definite relation between amount of shoot growth and nature of root treatment cannot yet be stated. If they follow the lines of Pickering's results, the second season's growth rather than the first is the more likely to show a differential effect. The trees which were lifted at the end of the growing season do, however, present certain features which are so marked that they may be regarded as definitely established, and it is to them on this occasion that attention will be confined.

Twenty-nine of the thirty trees lifted for examination show generally the same type of new root-system being produced and the same method of origin. The odd case is so radically different in character that, in view of experience gained during the rootstock investigations, it may be stated without hesitation that the root-stock in this instance is not a Paradise type, but one of the free types which only produce adventitious roots with difficulty; it is therefore left out of consideration in the following notes. The remainder in all examples have produced new roots freely; although some are stronger than others, it is a difference of degree only and not of kind. Broadly speaking, the tree has made practically no use of the old root-system existing at planting time and has instead set to work to produce an entirely new one.

Relatively few persistent roots in any instance, and in many examples practically none, have been formed from any part of the original root-system except that portion of the main stock or butt which lies in the top three or four inches of soil immediately below the ground line, *i.e.*, from the collar of the tree. In this region what amounts to an entirely new system has been formed. From all parts of the surface of the old stock within that zone roots have been emitted freely. They present all the degrees of vigour, length and thickness to be expected from structures which in the extreme

case cannot be more than nine months old. The largest range from two to three feet in length with the thickness, at the base, of a lead pencil. Their age is varied ; some obviously must have appeared very shortly after planting, while the youngest are nothing more than root tips just breaking through the superficial tissues of the old root. Some are practically unbranched : others have already developed a relatively complex branch system. The result is a more or less dense rosette-like mass of new roots springing from the collar of the tree with the residium of the old root-system below, which in many cases is apparently dead or dying and so sparsely furnished with new growths that there can be no two opinions as to the portion which has during the season's growth functioned as an active root and is destined to form the future root-system of the tree. In the average case it is clear that, apart from a possible use which the old roots may have had as mere mechanical stays or anchors, they might have been cut off three or four inches below the ground level without the tree suffering appreciably. A more complete justification of Pickering's contention as to the uselessness of the finer roots in newly planted trees it would be difficult to picture.

Since in each of these cases with the Paradise type of root-system new root formation has proceeded on the general lines just described, it follows that the special treatment to which the individual trees were subjected at the time of planting, whether at the root or in the head, has had no material influence on the character of the new root-system as a whole. It has been practically immaterial whether the old roots were left untouched or trimmed down to a bare stump. Whether or not the differential treatment has any influence on the vigour of the new root system produced is a point which is not clearly shown by the limited number of trees which have been lifted. Without very decisive differences in strength following individual kinds of treatment no safe conclusions could be drawn from the small numbers of each class already examined ; there are certainly no such differences to be seen uniformly. On the whole the balance of strength is in favour of those trees the roots of which were cut hardest ; but this may be due quite as much to a difference in vigour of the individual trees themselves as to the kind of root treatment. The course of the results with the remaining trees over the next four years should settle that point. The same position must be taken with regard to the effects of pruning and non-pruning the shoots at the time of planting. The pruned trees generally promise to lend themselves better to ultimate tree shaping and formation than the unpruned ; but no pronounced effect one way or the other shows so far in the root-systems, although there is on the whole perhaps an advantage in favour of non-pruning in the trees lifted this season.

The varieties of trees lifted on this occasion were Edward VII,

Stirling Castle and Whimple Wonder respectively. The differences as regards new root growth were of the order of strength only. The seat of origin was the same generally as described above. The King Edward VII trees were very weak maidens on the English Broad-leaved Paradise rootstock, and the amount of new growth, both of root and shoot, was relatively small. The Stirling Castle trees were distinctly stronger and made generally, for the variety, fair growth above and below ground. The third sort, a local Devon variety of distinct promise for farm orchard purposes, is a much more vigorous grower than either of the preceding and the trees were much stronger when planted. The new shoot growth, except in cases affected by Aphis attacks, was long and stout, and the new root-systems remarkably well-developed and vigorous, especially in those trees with the roots cut back to stumps at the time of planting.

Root formation in sand.—Passing now to the behaviour of the trees grown in pots of sand, a very superficial examination of the roots sufficed to show that an entirely different order of root development had taken place. Taking first the case of the trees which had had their old root-systems pared back to a single stump at the time of planting, an extraordinarily prolific development of new roots had occurred: but instead of the seat of origin being practically limited to the three or four inches of root in the collar region, as in the case of the trees grown in open ground, it extended over the whole root surface from the collar to the cut end of the stump. For its entire length the old root had produced a mass of new fibrous roots, and no special zone could be distinguished as carrying a greater wealth of new fibres than the remainder of the surface. The regions of most prolific formation were perhaps those in the immediate neighbourhood of the numerous cuts, now well callused, where the old roots had been excised, *i.e.*, in the regions of wounds deliberately made when transplanting. The character of the new roots also differed from that of those grown in the open ground. Instead of being more or less stout at the base and tapering gradually to a relatively fibrous tip, with lateral ramifications by no means numerous and of a simple rather than branched habit, the new roots in the sand were little more than fine threads, of great length in proportion to diameter and branching with the greatest freedom into a tangled mass of a very similar degree of fineness and length.

The trees which had been subjected to less drastic treatment at the root at the time of planting showed the same general features, although possibly to a somewhat less striking degree. There was the same tendency to free new root formation from base to apex of the old root-system with no marked zone of special activity, the same extra freedom around the callused surfaces of old wounds and injuries and the same excessively long, much branched and

thread-like type of new root. In other words, the preliminary root treatment in no obvious respect influenced the character of the new root-system.

To discuss properly the differences presented by the new shoot growth of these trees in sand and those in the open ground would involve the consideration of issues outside the immediate scope of this article. It is likely that there will be occasion to take up the subject independently before long; therefore nothing further will be said here beyond recording the existence of differences in the character of both the shoots themselves and the foliage, and the absolute freedom from Aphis attack shown by the trees in sand at a time when hardly any other trees at the Station were entirely clean.

There is nothing to record as to differences in amount of shoot growth made by the individual trees of these sand cultures, no relation between the nature of the root treatment and the amount of shoot growth being traceable.

Root formation in water.—The behaviour of the trees in water culture remains to be considered. The experiments were originally started with the primary intention of utilising them for direct observation of the course of development of the new root-system following the respective forms of root treatment already described, such observation being impossible in the case of trees grown in soil or sand. Within a few weeks of the commencement, however, it became evident that much more would be shown than the nature and sequence of new root formation. The consideration of the results observed which follows, will be deliberately restricted to the immediate subject of this article; the other aspects of interest must be left for a later separate paper, to which their significance entitles them.

New root formation in the water cultures proceeded on obviously different lines from that in either sand or soil.

The water cultures were started in March, 1920, and for the next month or six weeks practically no new roots appeared. It is known that at that season of the year the appearance of new roots either in sand or soil follows much more quickly and freely. In water, on the contrary, the root-system remained relatively in a state of stagnation. Within three weeks from the start the first signs of a remarkable sequence of events became apparent. Here and there on the old roots patches of a whitish slimy growth developed and these grew bigger and bigger until, with some of the trees, the whole existing root-system was more or less completely coated in a few weeks. This was particularly the case where the old roots had been pruned back to a single stump. It was least marked in the trees in which all the root fibres had been retained. Its nature and significance need not be further discussed here; but it may in passing be recorded that in each of the twenty-

four separate water cultures under observation the fungus present was apparently the same.

The condition of stagnation at the root in most cases slowly disappeared. The tips of a few isolated new roots began gradually to show themselves, forcing their way sometimes through the bark of the older portions of the root-system and springing sometimes as fine fibres from the smaller of the old roots, where old fibre had been left. A more noticeable development of root activity occurred in the way of lenticel growth. These structures, visible on dormant roots as very small dot-like patches of loose cellular tissue of the size of a pin's head no less, began to enlarge rapidly into pustular outgrowths which in due course grew into conspicuous excrescences of the size of a pea or larger. During the course of the summer, in the case of trees which remained relatively healthy under the water culture conditions, these pustules continued to increase in size until neighbouring ones fused; the result was an extraordinary-looking series of irregular warty masses distributed over the whole root surface.

It will be convenient in describing the sequence of events to refer indiscriminately both to new root formation and this lenticellular development under the general term of "root activity." Sometimes the one, sometimes the other, and sometimes both occurred concurrently: but whichever happened the behaviour of the fungus was the same.

As soon as any sign of "root activity" appeared at any portion of the surface of the old root-system the fungal growth in that region began to diminish. Within a week or two it disappeared entirely in its immediate vicinity, persisting, however, on other parts of the same root-system where "activity" had not yet shown itself. In some trees "root activity" was so well distributed that the fungus disappeared entirely and did not make its reappearance until towards the end of the growing season, when "root activity" began to diminish. In other cases "root activity" was more partial throughout the season and the inactive areas of the root showed the presence of the fungus during the whole summer. In a third type of case "root activity" never really became properly established, the roots remaining practically as dormant as when first placed in water culture, and then the hold of the fungus was never relaxed over the root surface as a whole, with the disastrous results to the tree to be duly recorded. Ultimately in every case as the end of the growing season approached "root activity" slackened to vanishing point. As that occurred the fungus concurrently re-established its hold and eventually more or less completely overran the whole root surface. At whatever period of the season it happened that it finally secured the upper hand, a new feature in due course followed, viz., the development of

growths of green Algae. By mid-autumn all the cultures showed the root-systems overrun with both fungus and Algae, accompanied by complete cessation of "root activity." The light-coloured superficial cells of the lenticellular outgrowths became discoloured to a dingy brownish tint and all new root production stopped.

Considering root development alone, it may be said that no uniformity in behaviour could be observed between individual trees subjected to the same initial root treatment. With some, new root formation started much earlier in the season than with others, the time being also apparently quite independent of the mode of preliminary treatment. The same irregularity held with regard to the number and size of the new roots formed, although in this respect the trees with the root-system reduced to a stump produced as a group appreciably fewer roots than the others. Some in fact produced none, a result which also occurred in a few cases in the other series. Most roots were formed on two trees on which all the original fibre had been retained, these springing generally from the smaller rootlets rather than the main roots and fairly freely from the finest fibres: but other trees of the same group showed no more new roots, and in some cases less, than those which had had all fibre removed. The place of origin of the new roots with all the trees was quite indefinite, being neither mainly restricted to the collar zone, as in the case of the trees in open ground, nor distributed more or less uniformly over the whole root surface as with the sand cultures, but simply dotted irregularly at intervals. It might, perhaps, be claimed that rather more freedom of production was distinguishable on the parts of the root within an inch or so of the surface of the water, but the number of new roots all told was generally so insignificant that the slight balance in favour of that region might have been accidental. It certainly was not a definitely positive result. New root formation in all the water cultures was immeasurably less than in soil and sand, both as regards number and length. In point of stoutness some were of appreciably greater diameter than the strongest of those in sand, but their length was relatively small. This deficiency in root growth was very clearly reflected in the shoot growth. The new shoots were short and fragile and the leaves dwarfed and more or less unhealthy in appearance. In many cases new shoot production was practically nil, the leaves were brown and scorched before the end of June and defoliation well advanced by the beginning of August. The condition of the foliage and the length of new shoot growth formed an almost exact index of the root condition. The greater the manifestation of "root activity" the greener and healthier the leaves and the longer and stouter the new shoots. There is reason to suppose that the better health of the "root active" trees was due at least as much to certain other factors concerned with the

aeration of the root-system as to the greater opportunity for intake of food substances: but further observations in this direction will be held over for a paper dealing particularly with that subject.

General Conclusions.

Having now dealt in a general way with the main features presented by the trees in these three series of experiments, the interpretation of the results and their significance must be discussed. Certain aspects which will more fully be opened up after the experiments have been in progress for a longer time will not be touched upon here, but definite conclusions on the other points already appear justified.

Influence of aeration.—In the first place, to anyone who has examined the trees only one conclusion as to the main determining factor for the nature and seat of origin of the new root-system in newly planted trees on Paradise rootstocks is possible. It is that of aeration. In the open-ground trees in the relatively close soil at Long Ashton new root production has practically been confined to the portions of the original root-system lying within three or four inches of the surface. In the sand cultures, with incomparably better aeration, the whole of the old root surface has been able to emit new roots freely. In the water cultures, with undeniably deficient aeration, new root formation has been precarious and irregular to a degree.

With new root formation shown thus to be readily possible at any part of the surface of the old root-system of a Paradise stock, given suitable conditions of aeration—coupled, it need hardly be said, with a requisite degree of humidity—it follows that the nature of the new root-system of a newly planted tree on stocks of this kind will be determined, both as to position and freedom of rooting, by the quality of the medium as regards aeration in which the tree is planted. It also follows that from this point of view the value to the tree of the root-system existing at the time of planting is variable, being dependent upon the nature of the medium in which planting is done. With a light open sandy soil more or less the whole of the original root-system may take part in the emission of new roots, although further tests are necessary to show what degree of lightness is required for this to happen. With soils of closer texture the range of old roots functioning in this respect to a material degree will be less; and under Long Ashton soil conditions the value of all parts other than the three or four inches of main root immediately below the surface of the soil is apparently almost negligible. In any case under ordinary conditions of planting the existing roots can only be regarded as the sources from which new ones spring; they do not appear to be capable of continuing their own growth

direct nor could this be expected, since in lifting a tree for transplantation it must be in the highest degree unlikely that the root tips, which are the regions where direct extension growth takes place, remain uninjured. Only in those exceptional cases where a tree can be lifted with a good ball of soil and carefully replanted at once in the immediate neighbourhood are root tips likely to be able to escape fatal injury and be capable of carrying on extension growth.

Stock Influence.—Under growers' conditions, therefore, the existing roots may be considered simply from the point of view of being possible originators of new roots, their utility in this respect being determined primarily by the nature of the medium in which they are planted. Now careful examination of the various points from which new roots have sprung in the cases above described has shown that, while aeration is the main determining factor, individual trees differ appreciably in the measure of their response, some producing practically the whole of the new growth in the " collar " region and others a small to moderate percentage on other parts of the old system. The one exceptional case, already mentioned as being almost certainly a free rootstock of the sparsely rooting type, seems to be so illuminating in this connection that its behaviour should have individual consideration at this point. It was one of the trees from the roots of which the fine fibres were removed and the ends of the remaining coarser roots pruned at the time of planting. No free new root formation occurred at the " collar," in fact only a single root of any size originated in that region. That one apart, practically the whole of the new roots sprang from the callused areas at the ends of the branching roots which had been pruned at planting time. At those parts whorls of new roots, none very strong, but most more than mere fibres, were formed.

Taking this case in conjunction with the remainder it would appear that the position of new root formation is determined in the first place by the nature or kind of the rootstock itself. With such as do not naturally form new roots freely from the older regions of the root-system aeration alone cannot induce a change of habit and the new roots are accordingly still produced from the youngest portions remaining of the old root-system. With free-rooting sorts, like the typical Paradise forms, the factors of age and aeration both come into play and work in opposite directions, aeration generally getting the upper hand. Possibly the anatomical structure of the root will be found to come into the question, but further consideration of that side must be deferred until the histological features of the respective root-types have been more thoroughly investigated. Such contending factors, however, can explain why individual trees on the same kind of rootstock differ somewhat as

regards new root formation: and it is noteworthy that as a general rule abundant root development in the " collar " zone is generally accompanied by little new growth on other parts, while somewhat less vigorous growth at that point is associated with more growth on the younger parts of the roots.

Up to this point, to avoid confusion in description, the portion of the tree actually situated in the soil has been referred to as the root-system. Strictly speaking from the botanical point of view, some degree of inaccuracy is thereby involved. Had the rootstocks concerned been all seedling stocks, the term would have been approximately correct; but, being with one exception Paradise types, the below-ground structures are not entirely true roots. The methods of propagation of Paradise stocks account for this. Such stocks, being propagated vegetatively by layering methods, possess a root-system which is entirely adventitious, *i.e.*, which is derived not from the original root of the parent tree of the type, but from true shoots which have thrown out roots themselves. The rooted stock as planted, therefore, is dual in character as regards its below-ground structures. The central axis, from which the primary roots are emitted, and which to the non-botanical mind appears as a main or tap root, is strictly a stem and the roots proper are the root-like outgrowths which arise from it. Its true shoot character is shown at times by the suckers which it throws up. It follows from this that the free root-formation in the " collar " region, described above, is arising for the most part from a stem instead of, as appears at first sight, the oldest portion of the root: and this fact brings to notice a third important factor—in addition to those of aeration and age of root already considered—in determining the point of origin of the new root-system.

Plants vary widely in their ability to produce roots from stem structures, the behaviour of cuttings providing a familiar illustration. Individual kinds of apples exhibit variations in the adventitious-rooting habit to a very marked extent, Paradise stocks rooting freely and free or seedling stocks in general with more or less difficulty. In the light of these facts the tendency of newly-planted apple trees to throw out the major portion of the new root-system from the " collar " region will be readily understood when a Paradise type of rootstock is used. Since the same considerations arise in connection with the use of other kinds of fruit stocks which are vegetatively propagated, it may be expected that further investigation will show that trees on quince rootstocks for the pear and the Pershore and numerous other types for the plum behave similarly. On the other hand, when trees are worked on free or seedling stocks their behaviour in the production of new roots is likely to be far less uniform. In such cases it is very difficult to decide with precision by external examination where the stem

portion of the stock ends and the root proper begins; but it is probable that in planting the tree not only the root but the basal portion of the stem of the stock is covered with soil. If that is so, the result will almost certainly be affected by the facility of the individual rootstock concerned in producing adventitious roots. One may expect to find, therefore, some trees following more or less closely on the lines already described for Paradise types and others producing new roots in quantity only from the younger portions of the initial root-system, aeration in their case being still a determining factor as regards extent of new growth.

This point was particularly well illustrated in one of the trees examined where an old injury at the " collar " had resulted in the cortical tissues being destroyed, and the vascular cylinder exposed for nearly one-half of the circumference in that region. No root formation on that side of the " collar " was accordingly possible. The collar rosette of new roots was thus one-sided and in sum total much less than it would have been, had the injury not occurred; a considerable part of the energy for new root production was diverted to the lower-placed parts of the old root-system, which formed much more new growth than usual as a result. Appearances suggest that the individual tree is capable of a certain effort at new root production after transplantation, and that if circumstances prevent new roots being formed in positions where external conditions are most favourable for vigorous growth it seeks the next best outlet for its effort.

From what has already been observed it is clear that the old root-system, even though it may remain unproductive of new roots, does not necessarily die quickly. Sooner or later death follows at the extremities of branches which remain " dead ends " and produce no new growth, but the results observed show that vitality may persist even after a whole season's inactivity.

Points of practical significance.—It is obvious, in view of the results described, that they have an important practical bearing on the methods to be adopted in the planting of young fruit trees. Some of the questions raised it is not proposed to discuss on this occasion, since it is desirable to allow the main scheme of the experiment to proceed further in order to see how the growth of the tree in future seasons will be correlated with the behaviour of the root; but there are other points which it is not premature to indicate.

Firstly, the degree of care to be given to existing roots of a tree about to be planted should depend upon the kind of rootstock used and the character of the soil in respect of aeration. It seems a complete waste of effort in the case of freely adventitious-rooting stocks like the Paradise on heavy soil to give the measure of care at the time of planting which is commonly accepted by growers as the standard form of treatment and advised in horticultural text

PLATE I.

Fig. 1.

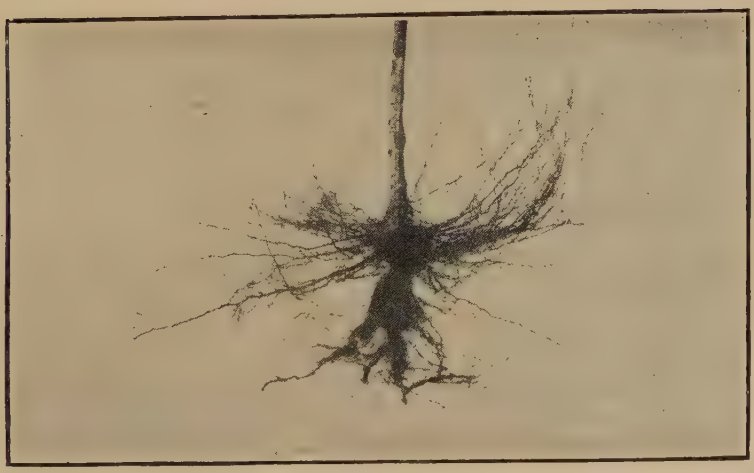

Fig. 2.

PLATE II.

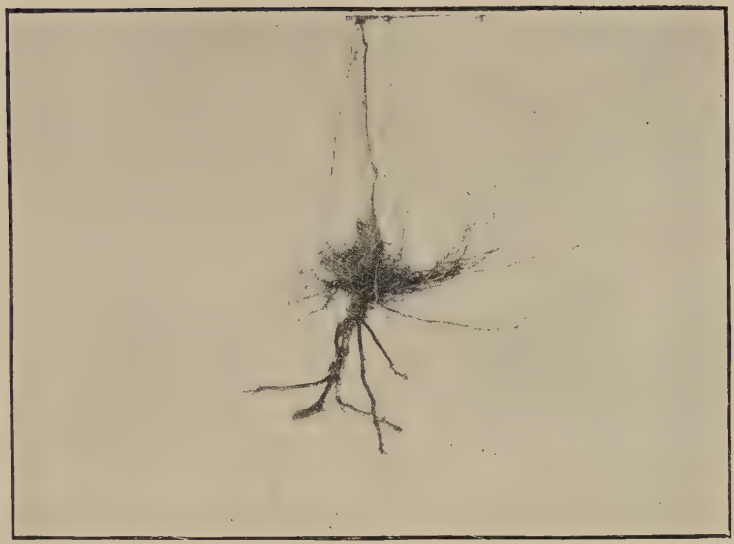

Fig. 1.

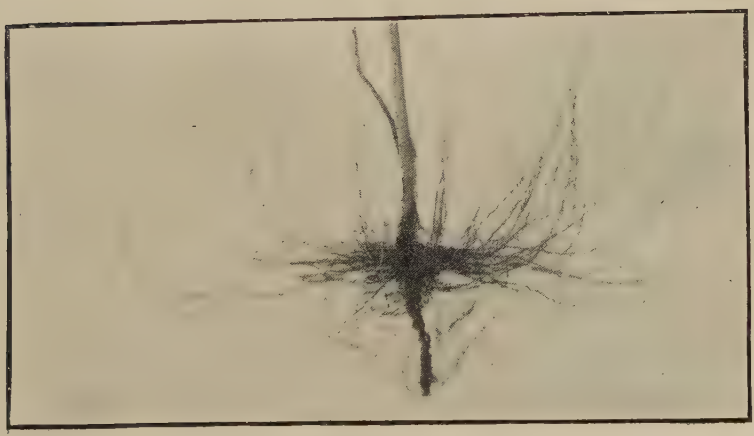

Fig. 2.

PLATE III.

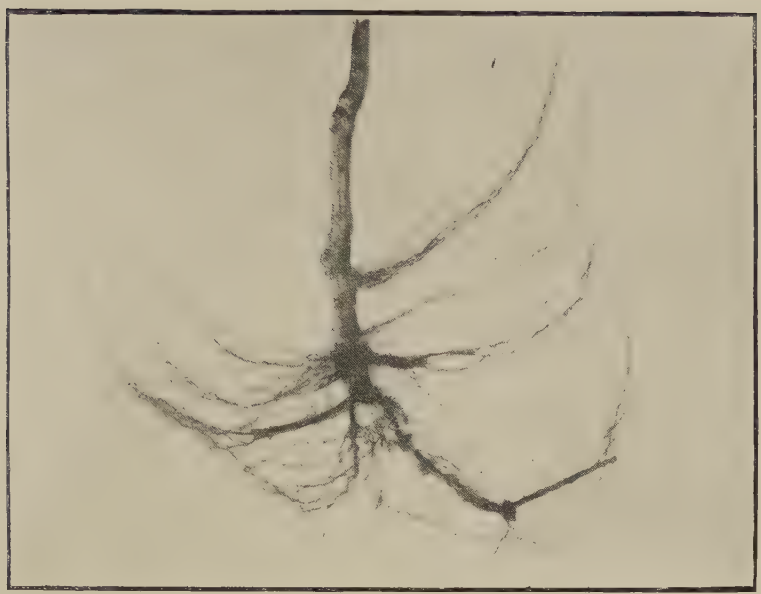

Fig. 1.

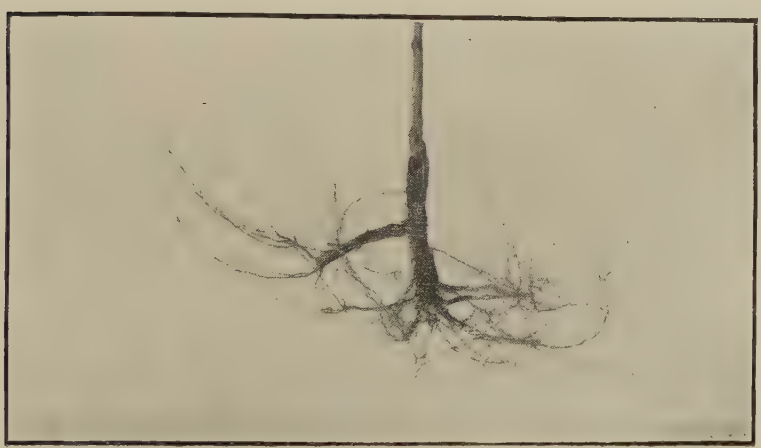

Fig. 2.

books generally. In these cases, notwithstanding the storm of criticism which Pickering aroused when he advocated disregard of fibrous roots in planting, there can be little doubt that he approached more nearly to sound economic practice than he was given credit for. Had he discriminated in his methods according to the soil and root types to be dealt with, his position would have been unquestionably sounder; for, since so many of the seedling or free stocks do not produce adventitious roots freely and, therefore, have to rely primarily on the new outgrowths from the existing roots, it follows that in their case the more of the original root-system which can be preserved the greater is the area from which new roots can arise. Even in these instances, however, the finest root fibres seem to be of relatively little practical utility, the new roots which count being produced from coarser roots. Until further investigation of the behaviour of free stock types has been made, it would be at least injudicious to recommend any drastic change from accepted methods.

Secondly, since aeration obviously plays so important a part in the extent of the development of the new root-system, the need of providing the best possible soil ventilation cannot be too strongly emphasised. Efficient drainage, deep preliminary cultivation, the lightening of heavy soils by the incorporation of suitable opening material, and the maintenance of a good tilth by surface cultivation during the growing season, especially that following planting, are methods which come at once to mind. Pickering's results, showing the beneficial effect of ramming the roots as firmly as possible in planting, may seem at first a little difficult to account for, because the ramming of the soil must tend to consolidate it to an extent sufficient to reduce soil ventilation around the original roots; but a possible explanation appears to be that by rendering conditions unfavourable to new root growth in that region the effort of the tree is concentrated on the production of new roots in the "collar" region, which not only get the benefit of good aeration by their nearness to the surface, but also possibly are kept relatively well supplied with water during the drier part of the growing season by the consolidated soil immediately below them. The question of soil moisture obviously has to be considered in connection with soil aeration and a suitable relation between these two factors for growth must be maintained throughout the growing season to obtain the best results in the way of new root growth. The water supply is certainly one of the limiting factors in root development. When deficient, it is undoubtedly a direct cause of checked growth; but when excessive, the evidence at present available is not sufficient to decide whether the harmful effect is direct, or indirect by the impairment of aeration, or a combination of both.

Thirdly, the stability of the newly planted tree in the soil must

be ensured. The importance of firm planting is probably universally accepted and it may appear unnecessary to say anything further upon a point which has ranked almost as an axiom : but these investigations have raised one or two questions in this connection which deserve consideration. The importance of avoiding undue consolidation of the soil will be apparent from the remarks in the last paragraph on the need of adequate aeration. At the same time the soil must not be left so loose that its water-lifting and holding capacity is impaired. The degree of consolidation clearly, therefore, should depend upon the nature of the soil. Its physical condition at the time of planting will have a definite effect on its ultimate state in this respect and the drawbacks of planting when the soil is over-wet will thus be readily appreciated. The more obvious point in firm planting is, however, that of preventing a loose roothold, which entails risk of breaking of new roots when the tree is subjected to wind. Now it is evident from what has already been said above that the case of trees on rootstocks which produce the new root-system from the younger portions of the old is different from that of those on rootstocks which provide the major portion of the root system *de novo* by adventitious root formation. With the former firm planting gives the old roots a good hold on the soil and they rapidly supplement this by the new and finer roots which they proceed to produce mainly from the callused ends of the smaller branches. In this way a firm grip of the soil is quickly secured and the tree soon can become self-supporting. In a word, the old roots play a vital and direct part in the maintenance of the stability of the tree. The other case is of a different order in that the old roots, so far as they have any value, act mainly mechanically and lifelessly. They produce little in the way of new roots and therefore cannot succeed in getting a direct grip on the soil. As they remain more or less inactive their hold must be loosened as time proceeds and the tree itself probably receives very little assistance from them by the time the growing season is well under weigh. This means that the main burden of anchorage is thrown on the newly formed roots given off in the " collar " region and the risk of damage to these must be considerable. Whatever may be done in the case of trees of the former class firm staking for those of the latter seems eminently desirable. Granted the need for staking them, the question then arises as to whether firm planting is not only unnecessary but actually a disadvantage. In so far as it tends to consolidate the soil and thus to render it less well aerated it may be argued that it is a positive disadvantage : but until direct experiment has settled the point its further consideration may be deferred.

Finally, while not attempting at this early stage of the work to suggest any particular form of root preparation or treatment prior

to planting as conducing to the best development of the new root-system, attention may be directed to the fact that so far the amount of new root growth does not appear obviously closely correlated with the preliminary treatment of either roots or shoots. Individual trees differ in a way which suggests the influence of an internal factor or factors more potent than the mere form of mechanical treatment, something which is covered by that nebulous expression, the " individuality " of the tree. Further research will possibly show the conditions under which a tree is grown in nursery quarters which are required in order to render it capable of the freest root production after transplantation. It must not be overlooked, however, that it may be the quality of the new root-system rather than quantity alone which is essential for the future welfare of the tree. It has been shown that, taking into account only those trees lifted for root examination after one season's growth from the transplant, the amount of new root growth does not correspond with the amount of new shoot growth. Some which have made very little shoot growth, for instance, have produced a relatively strong new root-system, and others *vice versa*. It does not, of course, follow that, had a second season's growth occurred before examination was made, this result would still have held. The tree with the bigger root-system may get the benefit of this in its second and subsequent years' growth and go ahead of its rival with the small root-system in spite of the better start of the latter in its first season. This would be in accord with the expectation of most growers and receives support from some of Pickering's observations in his experiments with rammed and unrammed trees ; for in those he found that it was only in the second season, as a rule, that the beneficial effect of ramming began to show in the shoot growth. One may at least conclude that, for the first season after transplanting, the amount of new shoot growth does not necessarily provide a measure of the amount of new root growth and that accordingly, it would be unsound to draw deductions as to the effect of any treatment given to a newly planted tree based on observation of the new shoot growth of the first season only. That being so it is evident that the further significance of the results recorded in this article must be awaited until the experiments have proceeded to a more advanced stage.

Description of Plates.

Plate I, Fig. 1.—Root-system of apple tree planted March, 1920, roots unrammed, and fibrous and fine roots not removed at time of planting : showing strong development of new roots in the " collar " region and little new growth from the original root-system below. (Paradise root-stock.)

PLATE I, Fig. 2.—As Fig. 1, but roots rammed at time of planting.

PLATE II, Fig. 1.—As Plate I, Fig. 1, but fibrous and fine roots removed at time of planting.

,, Fig. 2.—As Plate I, Fig. 1, but all roots except the main stump removed at time of planting.

PLATE III, Fig. 1.—As Plate II, Fig. 1: this tree being damaged at the "collar" region on one side and the wood exposed shows new root formation in that zone on the uninjured side only. Note the greatly increased root production from the lower parts of the old root-system as a result.

,, Fig. 2.—As Plate II, Fig. 1, but tree on free stock instead of Paradise. Note absence of "collar" rosette of new roots, the formation of the latter being confined almost entirely to the pruned ends of the old roots.

The upward direction of the finer roots is due to the trees being photographed in an inverted position in order to expose to view more clearly the behaviour of the old root-system.

FRUIT BREEDING INVESTIGATIONS.

By G. T. Spinks.

Fruit breeding work during 1920 has consisted mainly of the making of fresh crosses. Observations have also been made on the fruiting and other characters of seedlings raised in former years, but very few plants have come into bearing this year. In 1921, however, a number of young seedlings will have reached the fruiting stage. Brief particulars of the work done with each kind of fruit during the year are given under the various headings below.

Apples.—The following crosses among others were made :—

Annie Elizabeth × Wellington
Baddow Pippin × Cox's Orange Pippin
Court Pendu Plat × Sweet Alford
Cox's Orange Pippin × Allington Pippin
Ditto × Beauty of Bath
Ditto × Charles Ross
Ditto × King of the Pippins
Ditto × Lady Sudeley
Ditto × Lord Hindlip
Ditto × Reinette Obry
Ditto × Sweet Alford
Ditto × Wealthy
Devonshire Quarrenden × Cox's Orange Pippin
Gascoigne's Scarlet × Wellington
King Edward VII. × Wellington
Lady Sudeley × Sweet Alford
Ribston Pippin × Cox's Orange Pippin
Stirling Castle × Wellington
Sturmer Pippin × Sweet Alford
Warner's King × Wellington
Wellington × Charles Ross
Ditto × Ecklinville
Ditto × Golden Noble
Ditto × Lord Derby.

Seed has been obtained from all these crosses, but no seed was obtained from several other crosses which were made, but not recorded in the above list. On the whole the set of fruit was fairly good, but a severe attack of aphis caused much of the fruit to be very poor and the seed to be small. Also it was found that many fruits which had set satisfactorily contained very few seeds, this being especially the case with crosses made in the open. It was very commonly found this year that fruit, whether the result of artificial or of natural pollination, contained very few seeds. Apparently pollination had taken place, but not satisfactory fertilisation of the ovules, probably owing to unfavourable weather conditions. A number of suggested crosses could not be made owing to the widely different times of flowering of the varieties, and in future this difficulty will have to be overcome by collecting the pollen of the earlier flowering varieties, and keeping it until the later varieties are ready for pollination.

In making these crosses an aim has been made at definite desirable objects, including the production of a really good quality early dessert apple, a late dessert apple of good quality, and a good cooking apple which will be a late keeper. The desirability of heavy cropping qualities and resistance to disease are, of course, always borne in mind, and other qualities aimed at include a late flowering period, to secure immunity from frost, and such qualities as colour which are important from the marketing point of view. In breeding for dessert fruit Cox's Orange Pippin has been largely used as a parent in order to introduce the character of good flavour, while the other parent has been selected with a view to supplying the other desirable qualities. Wellington has been selected as the parent for providing high cooking quality in a culinary apple, and has been crossed with varieties which should supply various other characteristics which are wanted. Crosses have been made, or planned for next year, between market varieties and certain sorts of cider apples which are notable for their heavy cropping powers and their late-flowering habit : a cider apple of the sweet class, when used as a parent, may also introduce other useful qualities to a cross. Seed has again been obtained from open-pollinated fruit of several varieties with a view to raising families of seedlings of each of these varieties, as mentioned in this Report in 1919.

The seedlings from our older crosses, which have fruited before, have again borne fruit this year. The Medaille d'Or × Kingston Black seedlings have fruited well, some of them bearing heavy crops, and one or two may be of value as cider varieties. The inheritance of various characters is also of considerable interest. This year chemical analyses have been made of the fruit from each individual seedling, and the chemical composition of these fruits as compared with those of the parents is dealt with in another part of this Report.

There is at present nothing to report on the more recently made crosses, as none of the seedlings have yet come into bearing.

Pears.—Pear crosses were made here this year for the first time. The following crosses were made, all in the open plantations :—

Catillac × Conference
Ditto × Pitmaston Duchess
Comice × Conference
Durondeau × Conference
Louise Bonne × Conference
Williams' Bon Chretien × Conference

As in the case of the apples, although the set of fruit was fairly good, yet the yield of seed has been very poor ; fine large Catillacs have contained on the average only one fully developed seed in each fruit. In deciding on the above crosses the chief aim was that of combining good quality with cropping power. The production of a late-keeping variety of pear of commercial value is also being attempted.

Plums and Cherries.—The following crosses were made in the spring of 1920 :—

Cambridge Greengage × Victoria
Coe's Golden Drop × Victoria
Curlew × Denniston's Superb
Ditto × Jefferson
Giant Prune × Victoria
Heron × River's Early
Jefferson × Victoria
Pond's Seedling × Victoria
Victoria × Pershore
Victoria × Purple Egg

A few other crosses were made on trees in the open, but unfortunately no fruit set owing to the occurrence of rain and very strong cold winds immediately after pollination. Most of the parents were selected with the idea of obtaining crosses between distinctly different types of plums. Attention is also being given to the desirability of producing new varieties which will flower late, crop well, and be resistant to disease, particularly "Silver Leaf."

Germination of the seed from the 1919 crosses has not been good, but a certain number of seedlings have been raised. The seeds of the 1919 cherry crosses all failed to germinate. The stones were sown without being cracked and several months later the shells, though intact, were found to be empty, and it seemed as though they had never contained any kernels. This was also found to be the case in 1916, but as none of the stones were cracked before sowing, either in 1916 or 1919, it is not certain that they really were unfertile.

Currants and Gooseberries.—The following blackcurrant crosses and selfs were made this year :—

Baldwin selfed
Ditto × Seabrook's
Ditto × Victoria
Boskoop selfed
Ditto × Seabrook's
French selfed
Victoria selfed
Ditto × Boskoop
Ditto × Seabrook's

The Baldwin, Boskoop, French and Victoria bushes used in these crosses were true to the types as described in Mr. R. G. Hatton's classification, and were actually obtained from East Malling. Points aimed at in the raising of new blackcurrants are immunity to big bud and reversion, and as usual, cropping power and other good market qualities.

A few of the oldest blackcurrant seedlings have now been selected for propagation and further trial, while the rest have been discarded. Various characters of newer batches of seedlings have been noted, but these are not yet old enough to enable a final selection of the best plants to be made.

The following crosses and selfs were made with gooseberries in 1920 :—

Careless selfed
Crown Bob selfed
Ditto × Muttons
Keepsake selfed
Keepsake × Muttons
Langley Gage selfed
Whinham's × Muttons
Whitesmith selfed
Ditto × Muttons

It will be seen that in making the above crosses attention was largely concentrated on the endeavour to produce gooseberries immune to American Mildew, hence the use of the variety Muttons as a parent, as it is said that this variety is not attacked. Most of our gooseberry seedlings have not yet begun to bear fruit in any quantity, so that very little selection has been done from the older seedlings.

Raspberries.—The following crosses of raspberries and other *Rubi* were made in 1920 :—

Alexander Autumnal × Royal
German Everbearing × Northumberland Fillbasket Thornless
Ditto × Royal
Ditto × Park Lane
Northumberland Fillbasket Thornless × Royal
Ditto × Schaffer's Colossal
November Abundance × Northumberland Fillbasket Thornless
Ditto × Park Lane
Park Lane × Northumberland Fillbasket Thornless
Park Lane × Royal
Ditto × Schaffer's Colossal
Blowers × Taylor's Prolific
Hoosac Thornless × Agawam
Kittatiny × Himalaya
Ditto × Taylor's Prolific
Rubus laciniatus × Himalaya
Ditto × Loganberry
Taylor's Prolific × King's Acre Berry
Ditto × Kittatiny
Ditto × Mammoth

Seeds have also been obtained from selfed or open-pollinated fruits of the F_1 plants obtained by crossing in previous years. During the fruiting season a search was made in the neighbourhood for really good wild blackberries, and four plants were selected. These will be propagated and tested and plants will also be raised from their seed. There should be a demand for a really good cultivated blackberry, and it is possible that some of these selected plants, or their seedlings, will be worth cultivating. In any case they will probably be useful as parents in making crosses.

The plants obtained from crosses made in 1916 have now fruited for three years and the best of them are being propagated for trial in larger numbers, while the rest of the F_1 plants have been discarded. Attention is being paid, amongst other things, to the desirability of extending the fruiting season of the *Rubi*, and to the production of varieties with distinctive new flavours and other qualities which will make the fruit suitable for preserving and bottling.

Strawberries.—The following crosses have been made this year :—

Bedford × Keen's Seedling
Duke × White Perpetual
Earl × Unique
King George V. (Laxton's) × Black Prince
Ditto × Duke
Ditto × White Perpetual
La Productive × Keen's Seedling
Laxton's Latest × Black Prince
Louis Gauthier × White Perpetual
Maincrop × Laxton
Ditto × Royal Sovereign
Monarch × Royal Sovereign
President × Keen's Seedling
Ditto × Maincrop
Ditto × St. Antoine

Queen × British Queen
Reliance × Maincrop
Royal Sovereign × British Queen
Ditto × Keen's Seedling
Ditto × King George V.
St. Antoine × Earl
Vicomtesse × Earl
Ditto × King George V.
Ditto × Reward

The system is being followed of selecting for each desirable character one or two parents which have that character well developed. For instance, Laxton's King George V. is selected for earliness and Vicomtesse and Keen's Seedling for heavy cropping. Then each of these varieties is being crossed with several other varieties, which are notable either for the same character, in order to get that character intensified in the hybrids, or for other good characters, in order to obtain a new combination of good characters in the hybrids.

The plants from crosses made in 1916 or in earlier years have been reduced in numbers, only those being kept which appear to be worth further trial. These selected plants have been propagated by runners and at this stage five young plants from each selected seedling are being grown. After another two or three years the numbers of individual varieties will be still further reduced by selection, but the selected varieties will be tried in still larger numbers. Consecutive batches of new seedlings will be dealt with in the same way.

Plants from seed obtained in 1919 were planted out in the spring, but were not allowed to fruit this year, and they have made strong crowns which should fruit well in 1921.

Tomatoes.—A number of Tomato crosses were made in 1919, and an F_1 generation was grown this year. Breeding work with tomatoes is rapid, as a fresh generation can be raised each year. F_2 plants obtained from seed of the self-pollinated F_1 plants will be grown next year, and as some interesting results should then be obtained, details of the work will be reserved until those results are available. For the present it is sufficient to say that the F_1 plants are on the whole intermediate in character between their parents; but as expected, some characters are dominant over others; for instance, red colour of the fruit is dominant to yellow colour. Also all the F_1 plants from any particular cross appeared to be identical, which was perhaps to be expected as the parents breed true. Segregation of the various characters is to be expected in the F_2 generation.

*A METHOD OF IDENTIFYING REVERSION OF BLACK CURRANTS.

By A. H. Lees.

"My experience in inspecting growers' plantations is that not one per cent really knows when a bush is reverted and when not." Mr. W P. Seabrook in the "Fruit Grower," November 4th, 1920.

With this dictum the present author heartily agrees. It is, of course, no discredit to the fruit grower that such is the case. There is undoubtedly great difficulty in identifying slight cases as the disease is very insidious in nature. In most diseases there is a distinct and well marked change in the appearance of the plant which soon makes itself evident even to the inexperienced eye. Thus a leaf attacked by mildew changes in colour from green to whitish, or by scab from green to blackish. One does not find for instance that a mildew causes a change of colour from green to light green, and then to greyish green and then gradually to white. The change is abrupt in the spots where the mildew has attacked and therefore identification is not difficult. The case is quite otherwise with reversion. In its initial stages there is no very obvious change in the colour of the leaf nor is there any very obvious change in the shape of the leaf. It is only after the disease has advanced to some degree of intensity that a change becomes noticeable to the uneducated eye. Even then the colour change is but slight and the chief difference is in the shape. In other words in most diseases the change induced is discontinuous in nature while in reversion the change is continuous and quantitative rather than qualitative.

These facts have made the identification of the disease from the growers point of view, a very difficult one and it is not surprising therefore, that most growers cannot recognise it until it has reached a comparatively advanced stage. Nevertheless it is obvious that it is extremely important that some method should be found that would enable anyone inexperienced in the disease to come quickly to a conclusion as to whether any given bush in his plantation showed signs of it or not. The great losses of crops entailed by it

* This article has appeared in the *Journal of the Ministry of Agriculture*, and permission to reproduce it here almost simultaneously is gratefully acknowledged.

are well known and in the present state of knowledge as regards the disease the only methods open to the grower to curtail its ravages are propagation from sound stock and rogueing. This latter process must be done both in his cutting beds and in his plantations in order to keep the disease in check.

The method about to be described has been tested during the 1920 season, and has been found to be uniformly reliable. It enables the observer to spot the disease in its earliest stages, and can be used as a means of identification from about the middle of May until the end of the season when leaf fall begins. On Plate IV. are figured seven leaves of the black currant. Fig. 1. is a perfectly normal leaf,while Figs. 2-7 represent various stages induced by increasing amounts of reversion. Confining attention for the moment to the normal leaf in Fig. 1. there are two main points to observe.

(1) *The Leaf Venation.*—The blackcurrant leaf venation is palmate in type. That is to say the chief veins spread out like the palm of the hand and in this case include five members. These veins all originate from the same point, situated at the extreme base of the leaf and run to the main points of the leaf, which for convenience have been labelled A, B, C, D and E. They may therefore be called main veins. The next point is to notice the number of subsidiary veins running from the median vein or midrib (that running to C) to points on the leaf margin. It should be noticed that since the vein running to D is a main vein, it is not counted amongst such subsidiary veins. The first one to count is the one immediately above it running from the mid-rib to the margin. In practice all the veins can be seen best from the underside. In Fig. 1, there are five of them numbered 1-5. Each of these may be called a submain vein and each ends in a point in the margin. It will be noticed that not all the points of the margin receive submain veins. As a matter of fact they are innervated by veins of a lower order which branch off from the submain veins. These, however, need not be considered as they are of no use in identifying the disease. The first character therefore in identifying the disease is that a normal leaf has at least five submain veins running from the midrib to a point in the margin. Sometimes the number may run up to seven, but it never descends below five. Usually the submain veins on each side of the midrib are the same in number though slightly different in position. It is immaterial which side is counted.

(2) *The Leaf Margin.*—The second point to note is the character of the leaf margin. In normal leaves such as shown in Fig. 1, the margin is finely serrated, and there are quite a number of pointlets which do not receive a submain vein. This may, if necessary, be reduced to a numerical basis, though in practice it is not usually

necessary to do so. Thus if one counts the number of pointlets not receiving submain veins between C and the sinus between C and D (marked X), one finds there are eight. Summing up, therefore, the characters that make a perfectly normal leaf are (*a*) at least five sub-main veins and (*b*) a finely serrated margin with many pointlets not receiving sub-main veins.

To bring out the points of difference it is best to compare a typical reverted leaf such as shown in Fig. 4. For convenience of reproduction only half the leaf is shown. This type is a very common one in reverted bushes and will be readily recognised by growers. Here the number of sub-main veins has been reduced to three, and the margin is noticeably coarse in outline. If one counts the number of pointlets between C and X, not receiving sub-main veins, one finds the number two as against eight in the normal leaf.

There are, therefore, well marked differences. So well marked are they that the practical grower may well say that he could tell the difference by eye, without going to the trouble of counting. Nevertheless the method has value as can be shown by consideration of the slighter cases of the disease. Figs 2-7 represent advancing stages of attack. While Fig. 1 is quite normal Fig. 2 is slightly attacked, Fig. 3 more so, and so on until an extreme type is reached in Fig. 7. At first sight Fig. 2 appears normal especially as it possesses five sub-main veins. The margin, however, is distinctly more coarsely serrated than Fig. 1 and has as a matter of fact only four pointlets between C and X which do not receive sub-main veins, as compared with eight in Fig. 1. It has, therefore, a distinct touch of reversion in its make up, and any bush having such leaves may be safely marked down as suspected. In Fig. 3 a further stage is represented, and here only four sub-main veins are found and the margin is still coarser, only two uninnervated pointlets being present between C and X. In Fig. 4, the next stage, only three sub-main veins exist and two uninnervated pointlets. Figs. 3 and 4 are very common types in cases of reversion and frequently no further stage in aberration of leaf type is reached. Sometimes, however, more extreme types are produced as in Figs. 5-7 where the sub-main veins are successively reduced to two and a doubtful, two and one. In Fig. 5 the third vein does not run to the margin, but is twined round in an inward direction. The uninnervated pointlets are reduced to zero in each case. Such types are frequently spoken of as " oak leaves " by growers. The term is a convenient one to use, but it must be distinctly understood that they grade into the more ordinary types of reverted leaves and are only extreme cases of the same.

It will doubtless have been observed that in Figs. 1 to 4, there is a successive comparative elongation of the leaf. As a matter of fact this is usually taken as one of the characters of a reverted leaf

PLATE IV.

by growers. The author, however, prefers not to lay emphasis on this character because, though frequently it is a reliable guide, a fuller examination of leaves in the field shows that it is not completely so. One can find cases where reverted leaves are quite broad in shape. The same applies to size. While it is perfectly true that in the majority of cases reverted leaves are smaller than normal this is not always so. For instance, if a reverted bush grown under good cultural conditions be cut down to the ground the growth made the following season has quite large leaves, which at first sight appear almost normal in shape as well, but their reverted state is quickly revealed by the method outlined above. Conversely small leaves are not necessarily reverted. Such leaves, really quite normal, are frequently produced at the beginning and end of the season.

For convenience of comparison the points already discussed have been summarised in the following table.

The method of identification described above has enabled the course of the disease to be followed in considerably more detail and with greater accuracy than hitherto. The results obtained cannot be described here through lack of space, but they have shown that a reverted bush may start the season by producing perfectly normal leaves. This, however, does not continue long, perhaps only for a few leaves, but it means that in the early part of the season no attempt should be made to identify the disease by this method.

Figure.	No. of sub-main veins	Character of Margin.	Serration	No. of un-innervated Pointlets.
1	5	Normal	Fine	8
2	5	Slightly Reverted	Fairly fine	4
3	4	Reverted	Coarse	2
4	3	Reverted	Coarse	2
5	2	Intermediate Oak Leaf	Very coarse	0
6	2	Oak Leaf	Very coarse	0
7	1	Oak Leaf	Very coarse	0

By the middle of May, however, reverted leaves begin to show and this time until the end of June constitutes the period in which the disease is most readily recognisable. This fact has long been known to practical growers who do their rogueing at this period of the year It can, however, be done at any later period until the leaf drops, though the process is not quite so simple. In July or August the May-June leaves will not be showing at the top of the bush and since the reverted leaf type is most marked in May-June more care must be taken. However, in many cases the July-August leaves are also abnormal, though frequently only to the

extent shown by Fig. 2. Nevertheless the grower who has trained his eye by the method described in this paper will soon be able to pick out such leaves. All he has to do then is to turn back the branches and look for the leaves produced in May-June. If reversion is present these leaves will show it quite clearly.

Practical Conclusions.—As mentioned above in the present state of knowledge as regards the disease the grower has two methods of attack. The first consists of propagation from sound stock. Now while nurseries in general do their best to send out sound stock, cases have been known in the past where reverted bushes have been received from firms of an established reputation. This statement is not made in destructive criticism as the author is fully aware of the great difficulties such firms experienced in ridding their stock of traces of the disease. But the risk still remains and is proved by the fact that no firm dare give a guarantee that the stock they send out is free from reversion. There is also a further point to consider and that is that in the present shortness of nursery blackcurrants, a grower cannot always obtain the variety he wants. It is therefore highly important that he should be in a position to propagate from his own stock should he wish to do so. In this case he should examine his bushes in June, and mark down individual bushes that are absolutely sound, as proved by the method described above. It is useless and dangerous to mark down blocks of bushes unless every bush in them is individually inspected, since in a block apparently normal to the eye, there are frequently some which show a trace of the disease. In the present stage of ignorance, therefore, it is necessary to be on the safe side, and only to use those that are beyond suspicion. Such bushes should be denuded of every scrap of wood that will serve for a cutting.

The second process of control open to the grower is that of rogueing. This should begin in the cutting beds and end in the plantation. Every year in June the cutting beds should be examined and every affected bush should be grubbed and burned. Exactly the same procedure should be adopted in the plantation except that here, since the bushes are fruiting, they should be marked in June, for destruction after the fruit has been picked. The best method of marking such bushes consists of breaking one or more small branches in such a way that they are not completely removed, but that the dead leaves indicate the disease without materially interfering with the crop. By adopting such methods one large fruit grower has practically eliminated the disease from his plantations.

APPLE BLOSSOM WEEVIL.

By A. H. Lees.

During the last two years the ravages of this pest have been particularly marked. In the heavy crop of 1919, its effect was not in the majority of cases particularly harmful, since the thinning of fruits caused by it was of advantage rather than the reverse. In 1920, however, where the apple crop was light in districts unaffected by the insect, the extra thinning caused by it very seriously reduced an already too thin crop. It is safe to say that its attacks caused many hundreds of pounds loss to growers.

The broad outlines of its life history are well known. Thus the beetle, which is a typical weevil, that is a beetle with a long snout and certain other peculiarities, comes out of its winter quarters in the early spring and proceeds to drill a hole in the young unopened flower and to lay an egg in it. This hatches soon afterwards, and the resulting grub feeds on the stamens and ovules of the flower. This results in most cases in the failure of the flower to open or of the fruit to set, but occasionally in self-fertile varieties like Worcester Pearmain a set seems to be obtained before the style of the ovary is destroyed. Much more frequently, however, destroyed blossoms fail to open, turn brown and finally drop.

Towards the end of May the larva changes to a pupa inside the capped blossom, and a little later emerges in the beetle form. It is at this point that the information as regards its habits is obscure. Some authors have maintained that no feeding takes place during the summer, and that hibernation ensues later without any nutriment being taken. Others, on the other hand, have asserted that the summer weevils feed on the lower surface of the leaves; which, if either, view is correct is uncertain. The possibility of poisoning them with lead arsenate would, of course, depend on their habits and it is highly desirable that the point should be settled. It is hoped that information will be forthcoming next year from work now being carried on at Long Ashton.

As the autumn approaches the beetles begin to search out a suitable spot for hibernation. They are said to spend the winter in rough bark, beneath stones or under any rubbish on the ground. In a visit to an infected plantation at the beginning of October, 1920, it was only with the greatest difficulty that any could be found

in the soil underneath the affected trees. Close by were some oldish plums, and in the old grease bands could be found a few specimens. A further investigation revealed a fair number in the cracks of the bark, but only on the old wood. If the wood was even moderately smooth none could be found. It was doubtless in the attempt to reach such cracks that a few had become caught by the old grease band. In larger numbers they were found sheltering under old grease band papers on some apples and here it was noticeable that if any were found, usually as many as fifteen or twenty were congregated together. They seem distinctly sociable. In this plantation a large number were found thus on the trunks of both plums and apples when the conditions were suitable, but of course, it does not follow that they may not select other positions, not so easily accessible, as well. They remain in hibernation till the following spring.

Prevention.

It has been noticed that growers who lime-spray thoroughly are far freer from attack than those who do not. The lime-spraying, however, might easily have two distinct and separate actions and to either or both the effect might be due. The coat that adheres to the trunk may completely seal the insects in and thus prevent their escape in the early spring, at a time when they would normally be on the move for egg laying. Or again there may be an indirect effect. Lime spraying usually delays the opening of the flowers for about a week. The insect lays its egg comparatively slowly, generally taking about three quarters of an hour over the operation. Further it will not oviposit in open flowers and therefore in a quick season the number of flowers attacked is comparatively small. A week in the spring often makes a considerable difference in the weather, and thus trees which are a week backward owing to lime-spraying may encounter much warmer conditions at the time of flower opening than would unsprayed ones. Thirdly the effect may be a mechanical one. The coating of lime may actually prevent the insect from getting at the flower in the required condition and by the time the lime coat has cracked the flower may be then already opening and therefore unsuitable for oviposition. It is hoped that in the course of work now in progress at Long Ashton, that these factors will be sorted out.

Even so, however, the process of lime-washing is an arduous and unpleasant one and an alternative method of control is highly desirable. Jarring the trees in spring has frequently been advised, but in the author's experience this practice has been attended with very disappointing results. It is possible that in the hands of others the method is more successful, but that no great success attends the plan would appear to be indicated by the fact that it is

not widely used. Grease banding as a method of control also seems to be useless since the beetles readily fly in warm and bright weather though they are sluggish enough in cold and dull conditions.

Spraying with lead arsenate in the spring also seems of little avail. This is not surprising when one considers the very small hole made by the weevil for oviposition and the consequent very small amount of tissue that is gnawed. The covering would have to be very effective indeed, and the spray used at a great strength to get any marked poisoning effect.

There remains the method of trapping and it is possible that this may prove the easiest way on a commercial scale. The insect has a marked inclination to hide itself at certain seasons of the year and possibly this inclination might be taken advantage of. Some experiments done in the Tyrol about a quarter of a century ago seem to show that though a good catch may be obtained in traps in October, a far better one is got in May. The month of May would, of course, be the time when the new generation of beetles had come out. It is rather surprising to find that they are willing to go into hiding at that time of the year. The author has found them at that time, just below the soil, at the base of an apple tree running up and down the trunk, though limited in their wandering by a grease band. It is possible that they feed during the summer and then retire to cover again. If this is their habit trapping in May should prove useful, since one would catch them before they had gone to some cover which could not be examined.

SPRAYING TRIAL FOR CONTROL OF LOGAN BEETLE.

By A. H. Lees and G. S. Peren.

The logan and raspberry beetle, *Byturus tomentosus* is the most serious trouble that the logan grower encounters and is the most usual cause for grubbing otherwise fruitful plantations. The beetle hibernates in the ground and appears above ground some week or two before the first logan flowers appear. As soon as the flowers open they enter them, often pairing in this position. Eggs are laid here and the resultant grub bores into the receptacle of the fruit. Its activity causes the fruit to slow down its growth and to become distinctly deformed in shape. As the berry grows the grub usually breaks into the fleshy portion of the drupels frequently rupturing the skin in the process. As soon as this occurs the fruit rapidly loses water through evaporation and consequently dries up. Its decay is frequently assisted by various flies which, as they suck at the open wounds, doubtless leave their quota of saprophytic organisms in exchange for their meal. The direct and indirect damages caused by the beetle comprise loss of size, shape and weight beside seriously injuring the canning quality. It is therefore a serious pest. So far no satisfactory commercial method of control has been found. Like most beetles it is very hard to kill with contact washes or powders. It is comparatively easy to anaesthetize it or to cause it to feign death, but to kill by such measures is very difficult.

In order to test whether it were possible to control it by spraying with lead arsenate a small trial was conducted in 1920 at Long Ashton. Soap was added to the arsenate in order to obtain rather better penetration into the flowers, where it was necessary to lodge the spray. In this case no scorching was obtained from the combination, though P. J. Fryer has shown that when the arsenate is not strongly basic or when the soap is rather strongly alkaline such scorching is almost bound to occur.

The following data refer to the arrangement of the experiment.

FORMULA.

Arsenate of Lead	6 lbs.
Soft Soap	10 lbs.
Water	100 gallons

Pressure of application 125 lbs. per sq. inch.
First application: May 19th.
Second application: May 27th.

The object was to perform the first spraying when approximately 2/5ths of the blossom was out, the second when approximately 4/5ths of the blossom was out. The endeavour was made as far as possible to spray right into the flowers.

There were twelve rows of logans. Half of each row was sprayed and half left unsprayed. The plantation had previously been under a cultural experiment, and for this purpose had been divided into four portions consisting of rows 1–3, 4–6, 7–9 and 10–12. In order to find the results of spraying, if any, the middle rows were selected for counting, namely, 2, 5, 8 and 11, and as many berries from the rows as possible and as frequent pickings as possible were counted. In Table I. the results are set out under the different rows. The percentage of infected berries (right hand columns), varied from 19–28 for the non-sprayed, portions and from 11–22 for the sprayed portions. Totally, all the figures gave 15% for the sprayed portions against 24% for the unsprayed, showing a reduction of 9% or rather over half. The reduction is therefore clearly marked and shows that the spray had some effect, though the amount is somewhat disappointing.

In the second table the percentages of infected berries are calculated for each picking for both sprayed and unsprayed portions of all four plots.

TABLE I.

INFECTED BERRIES (percentages).

DATE OF PICKING.	ROW II.		ROW V.		ROW VIII.		ROW XI.	
	SPRAYED.	NOT.	SPRAYED	NOT.	SPRAYED.	NOT.	SPRAYED.	NOT.
June 28 . .	18	15	..	..	..	..	..	..
June 30 . .	12	9	8	14	4	16	8	7
July 5 . .	8	22	5	15	..	..	..	..
July 12 . .	20	41	20	33	19	28	13	25
July 26 . .	37	65	41	31	36	41	21	20

It is clear from these figures that in the nonsprayed portions there is a well marked increase in the number of infected berries as the season advances. This is due to unknown causes, but

TABLE II. SHOWING NUMBERS OF SOUND AND INFECTED LOGANBERRIES.

II				V				VII				XI				TOTAL			
SPRAYED.		NOT.		SPRAYED.		NOT.		SPRAYED.		NOT		SPRAYED.		NOT.		SPRAYED.		NOT.	
Sd.	Inf.	Sd.	Inf.	Sd.	Inf.	Sd.	Inf.	Sd.	Inf.	Sd.	Inf.	Sd.	Inf.	Sd.	Inf.	Sd.	Inf.	Sd.	Inf.
58	14	96	18	84	7	156	26	110	5	124	23	55	5	139	10				
93	19	85	14	264	14	306	54	85	20	75	29	83	12	241	80				
111	15	59	6	24	6	86	42	107	59	78	54	66	18	138	35				
299	25	244	68	30	19	62	28												
61	15	104	73																
33	19	36	66																
655	107	624	245	402	46	610	150	302	84	277	106	204	35	518	125	1563	272	2029	626
14%		28%		11%		20%		22%		28%		15%		19%		15%		24%	

may be attributed to the increasing number of beetles that come out of winter quarters as the season progresses. There is also a slight indication in row II of a reduction due to natural causes for the date of June 30th, but this is not sufficiently supported by figures to be reliable. The figures for the sprayed portions follow the general trend of the non-sprayed, but they are in nearly every case markedly less. They also show a reduction for July 5th, which goes against the direction of the unsprayed portions. This may therefore be put down to the effect of spraying. The conclusions therefore that may be drawn from the experiment are as follows :—

(1) That spraying reduced the total percentage of infected berries from 24 to 15.

(2) That the number of infected berries in the control portions increased markedly as the season progressed.

(3) That the effect of spraying was less marked as the season progressed.

This would indicate the desirability of a third spraying.

A BACTERIAL INFECTION OF PLUM TREES.

By S. P. Wiltshire.

In August, 1919, the trunk of a full sized plum tree, about seven years old, was received from Pershore for examination. The tree was diseased throughout the whole of the main trunk, the most badly attacked portion being about 3ft. 6ins. from the soil level. The cortex was killed and sunken over a very large area, which at one place completely girded the stem for about 6ins. That the disease had been developing for some months was evident from the fact that no growth was made during the year 1919, and the renewed development of wood of the live portion frequently produced a characteristic ridge between the dead and live areas on the outside of the stem. Four areas, scattered irregularly about the stem were noticeable bearing early stages of fructifications similar to those of a species of *Cytospora*. The largest of these areas measured 10cm. long by 4 cm. broad, the others being not larger than 4cms. by 2 cms. The stem was sectioned at six different levels, about 11cms. apart. Each section showed a considerable portion of the woody elements dead or dying, especially the three upper sections, where the wood was almost entirely browned.

Microscopic examination was made of the wood and cortex at the different levels. Both tissues were invariably infected by fungous mycelium—the cortical layers especially being heavily attacked. In many sections of the diseased cortex, however, certain gelatinous masses, with numerous small, rod-like bodies embedded in them, were also found, which strongly resembled small encapsuled bacteria.

A tree affected with a similar disease, in which bacteria were present in the cortex, was received by Mr. Spinks, two or three years ago, and during the past two years a number of trees have been attacked at this Station by a disease apparently similar in type. From six of these trees, bacterial like masses have been recognised in the cortex, together with very numerous fungal hyphae and in one case, fructifications of *Cytospora* were developed very extensively.

Of the six trees mentioned above, the first was a young half standard of the Kentish Bush variety, about three years old. The

leaves were formed normally in the spring, but in June the whole foliage wilted suddenly, and was followed by the complete death of the tree, the leaves of which turned a deep brown and remained hanging on the tree. The root showed nothing abnormal, but the stem bore immature fructifications of a fungus similar to those of *Cytospora* a little above ground level. These fructifications were the centre of a sunken area about 27 inches in length, and which at the worst portion embraced two thirds of the circumference. Cross sections of the wood showed it to be almost completely diseased at the level of the fructifications, but 15 inches above and below the stem was quite healthy. Similar bacterial like masses to those before observed were present in the cortex, in addition, however, to numerous hyphae.

The second and third trees were Victorias about 5 years old and growing in the same row. The first signs of disease were noticed in July, when the leaves began to turn yellow. At that time the trunks were both heavily diseased throughout their length, and in one case showed extensive pycnidial fructifications of *Cytospora sp.* The yellowing was followed by premature ripening of the fruit and early fall of the leaves. Bodies resembling bacteria in addition to numerous fungal hyphae, were found in each of the trees at the time when the first yellowing of the leaves occurred.

The fourth tree was of the variety Prince of Wales, and the only evidence of disease was a small sunken portion in the main trunk, extending from about 3 feet from the ground to the crown. No fructifications were visible, but on sectioning the cortex, numerous hyphae together with the same bacterial looking masses were recognised.

The fifth tree was also of the Prince of Wales variety and died off in the spring of 1920. Numerous bacteria and fungal hyphae were found in the main trunk and later the fructifications of the *Cytospora* appeared.

The sixth tree was on the variety Ickworth Impératrice, and died off during August 1920, in a similar manner to those recorded above. Masses resembling bacteria have been obtained from the trunk and branches of this tree also, and recently the fructifications of *Cytospora* have appeared.

In addition to these cases, various other specimens have been found to contain bacteria. Three specimens from Wales (which were kindly obtained by Mr. Wolf) each showed the bacterial like masses in the cortex. There appears to be no doubt that the occurrence of these suspicious looking bodies is fairly general in trees of various varieties affected with dieback.

At first these bacterial like bodies were regarded with great suspicion as it was thought they might simply be manifestations of gumming so common to injured plum trees. During the summer

months by cutting off a slice of the diseased cortex of a suitable specimen, cream coloured masses of the reputed bacteria can be squeezed out from those tissues adjacent to the healthy stem. The shape and ready staining, and also their occurrence at the edge of the diseased tissue inclines one strongly to the opinion that they are bacteria. Many attempts to culture these bacteria have been made, but only during the last summer was any growth obtained which might be considered as likely to be that of the organism concerned. Until the organism has been satisfactorily isolated, cultured and inoculation experiments carried out one can only surmise as to its pathogenicity, although the association of the bacteria with the disease in such a number of cases is extremely suggestive and appears to be more than an accidental occurrence. The relationship between the bacterial organism and the fungus *Cytospora* is only a matter of conjecture and the study of this fungus as well as the bacteria has been proceeding during the past season, with a view to determinating what part each of these organisms plays in the disease.

THE BARK CANKER DISEASE OF APPLES.

By S. P. Wiltshire.

During the past season an interesting disease appeared on apple trees in various plantations at Long Ashton. So far as is known the disease has not been recorded hitherto for this country, although it has been known to exist in the United States for some years. A brief account may, therefore, be of interest pending further investigation.

The disease is caused by the fungus *Myxosporium corticolum*, Edgerton. It attacks the main branches of the tree and produces large characteristic scars. These are long and may extend great distances along one side of a branch. The cortex over the scar is much sunken, and the edge of the scar sharply defined. The growth of the scar is marked by the formation of successive cracks and these developed at comparatively long distances from the edge of the infected tissue. By the growth of the scar the branch is surrounded and finally the top part dies away.

On the surface of the scar, numerous fruit bodies of the fungus are produced and in damp, foggy weather, the white spores of the fungus are found clustered together at the mouth of the fructification.

In America the disease is not regarded as being very serious as it appears only to attack trees which are in an unhealthy condition. The incidence of the disease at Long Ashton inclines one to this view also, although in those plantations where it has occurred it has done considerable damage, especially to the varieties James Grieve and Rival. The seriousness of the disease lies in the fact that the main limbs of the trees are destroyed and sometimes the whole tree is killed off. The latter is especially the case when the infection spreads from one branch to the head of the main trunk.

The entrance of the parasite probably takes place through wounds, as in many instances branches which have been headed back have become infected.

From the original description of the disease caused by this fungus, one gathers that the damage was confined to the outer layers of the stem, and hence the name of " bark canker " was given to it. This term is, however, rather misleading, as in the present outbreak the wood is discoloured for a considerable distance above and below the scar.

APPLE TREE CANKER.

By S. P. Wiltshire and G. T. Spinks.

In the report for the year 1919 a preliminary account was given of the infection of young buds by *Nectria ditissima*. During the present season, these observations have been extended considerably and many new facts regarding this type of infection obtained. It is not proposed here to discuss in detail the evidence of the manner in which the fungus infects the tree since this will appear elsewhere in due course; but merely to state that the cracks which occur in the leaf scar tissue appear to afford the fungus a means of entrance.

An important and somewhat disappointing discovery was made during the year in connection with the time of infection. In the report of the preliminary spraying trial made on the Medaille d'or and Kingston Black crosses in December, 1919, it was mentioned that no information was available as to the time infection took place, although seeing that the 1919 wood was not infected at that time, it was presumed that infection took place during the late winter and spring. As a matter of fact the first case of bud infection on the 1919 wood was found on March 31st, 1920. Twelve days later many infections in early stages of development were found, and infection was evidently progressing rapidly. At that time the trees were just breaking into leaf and there appeared to be a definite correlation between the time of bursting into bud and of infection by the canker fungus. With regard to the present season's growth of these crosses, no bud infection has taken place up to the present time, and it appears that the period of infection does not start before the spring and proceeds actively when the buds are bursting. Unfortunately other varieties do not behave in this manner. As early as September 23rd, 1920, many of the leaves of the shoots formed in 1920 had fallen off especially on the varieties King of the Pippins and Devonshire Quarrenden. On these two varieties numerous bud infections were observed even before defoliation was at all complete. The autumn infection increases the difficulties of controlling the canker disease by spraying very considerably, although some results may yet be obtained with varieties which only infect during the spring.

A notable feature of the autumn infection was that as long as the leaves remained on the trees no infection occurred, a fact quite

in accordance with the view expressed that the infection takes place through the leaf scar tissue. The time of leaf fall varied slightly in individual trees of the same variety, vigorous trees maintaining their leaves longer than others. This was strikingly illustrated by the behaviour of two rows of trees of King of the Pippins —one row in one plantation defoliating late and remaining uninfected—another row of much older trees in poor condition early becoming heavily infected. Whether stock influence has anything to do with this result is unknown, but in any case the possibility of increasing the vigour of the trees by suitable manuring and so reducing the autumn infection of leaf scars appears to be worthy of consideration.

The result of applying spray last year was in some respects rather encouraging. Counts were made on May 19th, 1920, and showed that the total number of cankers which had developed on the 1919 wood of the sprayed branches was 62, whilst on the unsprayed branches 299 infections were counted. At this time the cankers were in a very early stage and probably many infections developed afterwards; a second count of the cankers on the same branches was therefore made on December 23rd, 1920, and it was then found that there were 179 cankers on the sprayed branches and 500 on the unsprayed. Before the spraying was done last year the cankers on the 1918 wood of the observed branches were counted. On the branches which were subsequently sprayed, 299 cankers were found, while there were 135 on the control branches.

There appears to be a decided decrease in the number of canker infections as the result of spraying. The trees experimented with are seedlings and therefore vary individually, but the fact that the counts for the 1918 wood gave a considerably greater number of infections on the branches which were chosen for spraying somewhat discounts this objection. At any rate the results are regarded as sufficiently promising to warrant further trials on similar lines, and it is proposed to carry them out during the coming year.

A DISEASE OF MICHAELMAS DAISIES.

By S. P. Wiltshire.

The following brief note refers to a disease of Michaelmas Daisies which came under notice in the course of the Advisory Work of the Station during the past summer (1920). On account of the serious loss which it was causing to one of the large raisers of these plants the case was investigated in some detail. In due course a detailed description of the work will be published, but in the meantime this note may be of service as a guide to treatment of this disease which is evidently of common occurrence in one of the most popular and widely grown groups of plants now used for floricultural purposes.

The symptoms of the disease are as follows :—The plants break into strong growth in the spring and appear to be growing well. A number of shoots, however, in the early summer, when they have reached about a foot high, show a yellowing of the bottom leaves. These leaves turn brown and die off completely. The growth of the affected shoots is checked so that during the mid-summer they usually appear dwarfed, and also frequently show the premature formation of the inflorescence. Sooner or later the affected spike dies off. The result is the loss of a number of shoots which if allowed to remain show up as unsightly blackened withered shoots. Sometimes one single shoot of a plant will remain healthy while the surrounding ones die. One or two plants in a row may be affected whilst adjoining ones are healthy. After the dying back of the spikes, new growth may start from the ground once more.

The first specimens were received from Worcestershire, but since then the disease has been observed in two places in North Somerset and there is evidence that the trouble is widely distributed.

The disease appears to be due to a fungus of the Fusarium type, which lives in the tissues of the stem and root. The death of the shoots is due to the growth of the fungus in the water conducting tissues resulting in the stoppage of the water supply to the shoot which consequently wilts and dies off. Examination of the roots shows the presence of the fungus in the outer layers even when the external appearance of the root is quite normal.

A fungus has been isolated from the diseased tissues, and preliminary inoculation experiments indicate that it is the cause of the disease.

Before the control of this disease can be attempted intelligently, considerably more information will be required concerning the causal fungus. Attention to the following point, however, should prove of value—Michaelmas Daisies are propagated normally by the division of the old roots. Stocks affected with the disease give out new roots which cannot be distinguished from those of normal healthy growing plants. The propagation of these infected stocks only serve to propagate the disease at the same time. Where the disease has only just made its appearance, of course it would be better to dig up infected plants and burn them, but when the plants are extensively diseased this procedure may not be deemed expedient. Plants suffering from the disease, however, should be carefully marked during the summer and even if allowed to remain should never be used for the production of new plants. An additional reason for this procedure is the fact that the disease may possibly be transmitted through the soil, and, by planting infected plants one not only serves to produce diseased progeny, but also bring about the infection of the soil against which treatment will be extremely difficult. At present this is the only recommendation which can be made beyond the burning of the infected material cut out of the affected plants and the vigorous enforcement of general plant hygenic measures.

SINGLE VARIETY CIDERS AND PERRIES, 1919-1920.

By Otto Grove.

In the table below will be found a list of the apples and pears tested during the season for their cider and perry qualities, giving the chemical composition of the juices and other particulars.

Upon the whole the ciders and perries of the 1919 vintage were good, but suffered to a certain extent from lack of body, this being due in part at least to delayed filtration resulting from congestion of work in the cider house throughout the season.

The average specific gravity of the freshly expressed juices was 1·0523, which is a little higher than usual.

As regards keeping quality, after about one year in bottle, there were no cases of cider-sickness, but several cases of ropiness developed during the summer and autumn. One of these was a very exceptional one, which appeared in a cider made from a mixture of about equal parts of Cap of Liberty and Kingston Black apples. The cider was bottled during the early summer and after a couple of months the whole stock turned ropy rather suddenly. The blend had an acidity of ·86% of malic acid when bottled. This high acidity would under normal conditions eliminate any danger of ropiness. On examination of the ropy cider it was found that the acidity had fallen to ·4% of acid. It is probable that in this case two sets of micro-organisms have been active, first, an acid-destroying organism, which by reducing the acidity below the safety margin gave the second, the ropiness bacterium, a chance of development. This complex type of disorder is being investigated more closely.

In the case of this particular cider, as soon as the ropiness had been observed, the cider was pasteurised by placing the bottles in a waterbath and slowly heating until a temperature of 140°F. had been reached. The bottles were kept at that temperature for 15 minutes. This treatment not only stopped further development of the disorder, but resulted in the slimy consistency disappearing in a short time. The cider ultimately became quite good in flavour but was disfigured by a slight stringy deposit.

Sharp Varieties.

No. 1 Jelly (new) was a very sharp cider with a clean dry flavour. Nos. 2 and 3 were not quite as good as usual for the variety, both rather thin ; the same was the case with the two first Cap of Libertys

(Nos. 5 and 6). No. 7 was decidedly better. No. 8 was very good with a pronounced aroma. No. 9 (new) was rather coarse in flavour. No. 10 had a fairly soft pleasant flavour and a good aroma. No. 11 (new) was without much character. Of the two Foxwhelps, No. 13 was decidedly superior. Tom Putt (No. 14) was fairly good, but went ropy ; this is another case of a cider in the sharp group being attacked by this disorder. No. 15 was quite a good cider and so was No. 16. No. 17 had a very good aroma and flavour, and No. 18 was generally considered the best cider of the season in the sharp class. Nos. 19 and 21 were fairly good samples of the two well-known varieties, whereas No. 20 was rather inferior. Of the Kingston Blacks, No. 22, 27, 28 and 29 were the best, all being very nice ciders, the rest were somewhat below the standard for this excellent variety.

Sweet Varieties.

Of the three Eggleton Styres, No. 32 was the best with a very good aroma and flavour. No. 30 was rather dry and thin. Both No. 33 and No. 34 developed ropiness after being in bottle for about 6 months. No. 35 was not quite so good as would be expected for this variety. No. 36, which was tested for the first time, gave a very good cider and promises to be a very useful sweet variety. No. 37 was a very good cider with a pleasant flavour. No. 40 was a good cider, and the same was the case with the two last sweet varieties, of which No. 42 had a rather peculiar but pleasant flavour.

Bittersweet Varieties.

Six samples in this class, Nos. 44, 46, 51, 53, 60 and 62, were found to be more or less attacked by ropiness after about 8 months in bottle. Unfortunately it is at the present moment impossible to say why so many cases turned up in this particular season. No. 43 was a very good representative of the variety with good body and flavour. No. 45 had a clean rather bitter flavour. No. 47 was somewhat coarse in flavour. No. 48 had a full bitter flavour and was a very useful cider. No. 49 was rather inferior. No. 50 had a pronounced fruity flavour and was a fairly good cider. No. 52 was quite good with good body and flavour. No. 54 was fairly good and No. 55 good with a full bitter flavour. No. 56 (new) was very bitter, but otherwise a good cider. No. 59 had a very aromatic flavour and was one of the best ciders in its class. No. 61 was a good fullbodied cider with good aroma and flavour.

Perries.

No. 63 was rather thin and inferior in character. No. 64 and No. 65 were quite good dry perries with good flavour. No. 66 and No. 67 were both fairly good. No. 67 threw down a very heavy deposit, but was otherwise excellent.

No.	Name of Variety.	District where grown.	Date of Making, 1919.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of Fermentation at 25° C.	Date of Filtering.	Specific Gravity May, 1920.
	APPLES—Sharp Varieties.								
1	Jelly	Breinton	Oct. 29th	1·052	1·25	·14	9·5	28/1	1·006
2	Butterbox	Newton Abbot ..	Dec. 18th	1·044	·49	·13	4·2	12/2	1·007
3	Gatcombe	Long Ashton	„ 22nd	1·053	·50	·13	4·7	16/2	1·007
4	Woodsell	Much Marcle	Nov. 26th	1·052	·69	·11	3·3	1/1	1·015
5	Cap of Liberty ..	Martock	„ 1st	1·050	·85	·25	3·4	20/1	1·016
6	„ ..	Kingweston	„ 11th	1·054	·95	·25	3·0	4/2	1·028
7	„ ..	Sutton Montis ..	„ 14th	1·058	·99	·23	4·2	1/1	1·033
8	Cherry Pearmain ..	Nunnington	„ 13th	1·056	·57	·26	5·1	29/12	1·017
9	Rank Shooter ..	Glastonbury	Dec. 16th	1·051	·76	·15	6·4	16/1	1·019
10	Ponsford	Chawleigh	Nov. 28th	1·050	·66	·11	5·4	6/1	1·019
11	Corpwick	Glastonbury	Dec. 22nd	1·053	·74	·15	2·6	11/2	1·019
12	Foxwelp	Nunnington	Nov. 11th	1·047	·76	·23	3·1	1/1	1·020
13	„	Ledbury	„ 12th	1·052	·90	·28	2·2	2/2	1·026
14	Tom Putt	Nunnington	„ 26th	1·049	·56	·14	4·1	17/12	1·022
15	Porter's Perfection ..	S. Petherton	„ 27th	1·047	·62	·20	3·8	8/1	1·023
16	Bright Red	Breinton	„ 28th	1·054	·71	·23	3·7	7/1	1·023
17	Crimson King ..	Milverton	„ 21st	1·058	·63	·11	5·6	29/12	1·024
18	Backwell Red ..	Backwell	„ 14th	1·050	·67	·07	3·8	1/1	1·026
19	Frederick	Dingestow	„ 20th	1·053	·84	·10	4·0	5/1	1·027
20	Never Blight	S. Petherton	„ 27th	1·050	·96	·28	4·0	9/1	1·030
21	Lambrook Pippin ..	„	Feb. 3rd	1·047	·61	·11	2·1	1/3	1·030
22	Kingston Black ..	Long Ashton	Nov. 13th	1·049	·41	·13	4·0	17/12	1·016
23	„ ..	Breinton	„ 7th	1·063	·69	·22	3·2	28/1	1·017
24	„ ..	Ledbury	„ 12th	1·058	·65	·20	3·1	2/2	1·019
25	„ ..	Byford	„ 7th	1·060	·50	·25	2·9	19/1	1·025
26	„ ..	East Harptree ..	Oct. 29th	1·056	·62	·20	2·5	12/1	1·026
27	„ ..	Kingweston	Nov. 17th	1·065	·68	·17	4·3	22/1	1·029
28	„ ..	Martock	„ 1st	1·056	·59	·24	2·0	12/1	1·033
29	„ ..	Kingweston	„ 11th	1·056	·63	·20	4·0	15/12	1·034

	Sweet Varieties.									
30	Eggleton Styre ..	Long Ashton ..	..	„ 19th	1·058	·26	·12	5·8	29/1	1·005
31	„ ..	Ledbury ..	..	„ 25th	1·060	·31	·18	8·3	31/12	1·018
32	„ ..	Byford ..	..	Oct. 31st	1·054	·25	·18	4·5	12/1	1·022
33	Sweet Blenheim ..	Milverton ..	..	Nov. 14th	1·051	·28	·10	5·7	15/12	1·010
34	Hancock's Seedling ..	„ ..	..	„ 26th	1·057	·37	·16	3·6	28/1	1·013
35	Slack-ma-Girdle ..	Newton Abbot	..	Dec. 17th	1·054	·23	·13	3·4	10/2	1·014
36	Hogshead	Byford ..	..	„ 8th	1·042	·39	·11	4·5	7/1	1·016
37	Red Cluster	Alphington ..	..	Nov. 20th	1·046	·21	·15	3·7	8/1	1·018
38	Sweet Alford	„ ..	..	„ 17th	1·053	·19	·16	3·6	20/1	1·019
39	„	Long Ashton ..	..	Oct. 21st	1·048	·30	·14	5·2	8/12	1·020
40	Pytheres	Dingestow ..	..	Nov. 20th	1·046	·28	·17	7·6	15/12	1·023
41	Improved Pound ..	Killerton ..	..	„ 14th	1·053	·20	·15	4·0	3/1	1·026
42	Red Worthy	S. Petherton ..	..	„ 20th	1·054	·26	·18	2·8	8/1	1·040
	Bittersweet Varieties.									
43	Royal Jersey ..	Long Ashton ..	..	„ 13th	1·050	·22	·26	2·0	20/12	1·030
44	Royal Wilding ..	Ledbury ..	..	„ 25th	1·063	·25	·35	6·7	30/12	1·018
45	Strawberry Norman..	Breinton ..	..	Oct. 28th	1·056	·30	·45	5·6	12/1	1·014
46	„ ..	Long Ashton..	..	Nov. 13th	1·050	·24	·35	5·0	15/12	1·015
47	Master's Jersey ..	N. Cadbury ..	..	„ 13th	1·053	·25	·39	4·1	31/1	1·008
48	Chisel Jersey	S. Petherton ..	..	„ 27th	1·053	·26	·34	4·5	5/1	1·027
49	White Sweet	Kingweston ..	..	Oct. 21st	1·049	·23	·32	6·2	8/12	1·008
50	Portfill	S. Petherton ..	..	Dec. 8th	1·056	·26	·35	5·3	20/1	1·010
51	Dabinett	Long Ashton..	..	Nov. 17th	1·051	·21	·25	6·5	20/12	1·012
52	„	Sherborne ..	..	Dec. 19th	1·049	·19	·25	3·6	13/2	1·023
53	Large Sweet	Kingweston ..	..	Oct. 1st	1·055	·20	·20	3·6	8/12	1·013
54	White Jersey.. ..	Long Ashton ..	..	„ 2nd	1·048	·21	·18	5·6	8/12	1·015
55	Twistbody Jersey ..	Martock ..	..	Nov. 1st	1·052	·35	·33	3·4	20/1	1·019
56	Striped Apple ..	Kingweston ..	..	Oct. 29th	1·057	·25	·28	4·0	14/1	1·019
57	Early Bittersweet ..	„ ..	..	„ 6th	1·050	·21	·38	4·5	9/12	1·021
58	Medaille d'Or ..	Killerton ..	..	Nov. 13th	1·053	·19	·59	2·8	6/2	1·024
59	Teign Harvey ..	Newton Abbot	..	Dec. 18th	1·049	·42	·24	2·8	13/2	1·028

No.	Name of Variety.	District where Grown.	Date of Making. 1919.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of Fermentation at 25° C.	Date of Filtering.	Specific Gravity May, 1920.
	BITTERSWEET VARIETIES—*contd.*								
60	White Close Pippin ..	Sutton Montis ..	Nov. 14th	1·055	·26	·29	5·1	19/12	1·030
61	Greasy Redstreak ..	,, ...	,, 14th	1·057	·26	·27	5·0	19/12	1·032
62	White Norman ..	Nunnington	,, 11th	1·058	·27	·31	3·2	17/12	1·039
	PERRIES.								
63	Taynton Squash ..	Ledbury	Oct. 17th	1·048	·36	·07	6·2	8/12	1·009
64	Moccas	Breinton	Nov. 1st	1·052	·54	·16	11·0	10/1	1·009
65	Holmer	,, ...	,, 1st	1·053	·49	·10	8·0	12/1	1·011
66	Barland	Ledbury	Oct. 18th	1·057	·69	·34	6·6	12/12	1·018
67	Oldfield	,, ...	,, 31st	1·061	·60	·15	3·3	30/1	1·025
68	Butt	,, ...	,, 31st	1·055	·50	·33	3·1	29/1	1·032

TRIAL CIDER ORCHARDS.

By T. Wallace.

Owing to the failure of the apple crop during the past season, it was decided to postpone the proposed 1920 tour of inspection of the Trial Cider Orchards in Worcester and Hereford, until a more favourable cropping season, and consequently the work in this line during the past year has been restricted to the analyses of the soils of Monmouthshire which could not be completed in time for the 1919 Report.

The tabulated results of the analyses—mechanical and chemical—are given on Pages 94, 95.

An examination of the results brings out the following general points :—

Mechanical Analyses.

All the soils are derived from the Old Red Sandstone, and in consequence they show many points of similarity.

In general, three of the soils may be described as heavy loams and six as sandy loams. Except in one case (Tre Owen, surface soil) the predominant fraction in both surface soils and subsoils is the " Find Sand," which in the surface soils ranges from 39% to 23% and in the subsoils from 36% to 25%.

The " Fine Silt " fraction is always higher than the " Clay " fraction.

Chemical Analyses.

Organic Matter.—For pastures, the amount of organic matter as shown by " Loss on Ignition " is generally on the low side, ranging from 4.3% to 8%.

Lime.—The soils are generally deficient of lime. In six cases the surface soil and subsoil have " Lime Requirements," and in two of these surface soils, the acidity is equivalent to approximately 7 tons of calcium carbonate per acre.

In the three soils in which lime is present, the amounts are small, especially in the subsoils and it is evident that the lime has been " added " in the past.

It seems remarkable that the trees should have done so well on these acid soils, and it is hoped that we shall be able to carry out some " liming " experiments to see how much the trees benefit by " liming."

Phosphoric Acid.—The " Total " Phosphoric Acid is never high, being generally low, especially in the subsoil where in six cases there is less than 0.1% P_2O_5 present.

The " Available " figures are also generally low excepting at " Sunny Bank " where the orchard has had dressings of farm yard manure.

Potash.—Except in two cases, the " Total " Potash is generally high. An interesting point is brought out in comparing the " Total " Potash figures in the surface soils and subsoils. Of the eight cases available for comparison, in four cases the " Total " Potash is higher in the surface soils than in the subsoils,* in one case the amounts are equal and in three cases it is higher in the subsoils than in the surface soils.

In this connection, it will be seen that in the latter three cases the soils are of the heavier type whilst the remaining soils are of the lighter type.

The soils are discussed in detail below.

Llansaintfraed.—The surface soil only of this orchard was examined. This soil is a light sandy loam typical of the Old Red Sandstone and is similar in texture to the lighter soils of the Research Station. The acidity of the soil is equivalent to 4 tons of calcium carbonate per acre. It would probably respond to " liming " and general manuring.

Tre Owen.—The texture of this soil is good, although the percentage of " Fine Silt " is rather high. The " Available " Phosphoric Acid and Potash are low both in the surface soil and subsoil. No doubt the soil would respond to phosphatic manures and probably to potash. A dressing of slag should be tried. Both surface soil and subsoil are acid.

Itton Court (Cider Orchard).—The soil is a heavy loam, and where it is of sufficient depth the trees are doing well. At some points in the Orchard, the soil is only 6-8 inches deep and overlies a sandstone bed. In these latter places the trees are suffering from canker. This soil would probably respond to slag.

Itton Court (Perry Orchard).—The trees in this orchard are " doing " badly and the trouble is probably due to the texture of

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* C. V. Lydney Soil, Old Red Sandstone, 1919 Report, Trial Cider Orchards.

the soil. The "Mechanical Analyses" of the surface soil and subsoil show that the soil consists mostly of stones, gravel and sand, the proportion of the finer fractions present being very small. The trees do not appear to be able to obtain a firm "rooting" in this open soil, and it is doubtful whether intensive manuring will overcome the physical defects of the soil.

Tyllwydd.—This soil is a heavy loam of good texture. With the exception of the "Total" Potash, the food supply in this soil is very low and it would doubtlessly respond to liberal manuring. It has been found to respond to slag and superphosphate, but in view of the fact that the soil has an acid reaction, dressings of slag only are to be recommended. Heavy dressings of this manure should be given.

Sunny Bank.—This soil, the texture of which is on the coarse side, contains rather high amounts of "Stones" and "Coarse Sand" in proportion to the amount of "Clay" present. At one end of the orchard, the soil is also very shallow and here the trees are not "doing" so well, being subject to canker. The soil has been dressed occasionally with farmyard manure. Both the surface soil and subsoil have very high "Lime Requirements," viz., *Surface* equivalent to 7 tons of calcium carbonate per acre. *Sub* equivalent to 4 tons calcium carbonate per acre.

Croesheolydd.—This soil is a sandy loam containing a rather high proportion of "Coarse Sand" in both surface soil and subsoil, and has "Lime Requirements" very similar to those of Sunny Bank. This soil would probably respond to liberal manuring.

Llanddewi Court.—The soil is a sandy loam of fairly good texture. The "Available" Potash is low in both the surface soil and subsoil. The soil has an acid reaction. A dressing of lime should be tried.

The Hendre.—The soil is a heavy loam, similar in texture to Tyllwydd and Itton Court (Cider Orchard). The "Total" and "Available" Phosphoric Acid are low in both surface soil and subsoil (c.v. Tyllwydd), and the soil would probably respond well to liberal dressings of slag.

COUNTY CIDER ORCHARDS. PLANTED 1908-10.

MONMOUTHSHIRE.

MECHANICAL ANALYSIS	Llansaintfraed.	Tre Owen Dingestow	Itton Court (Cider Orchard)	Itton Court (Perry Orchard)	Tyllwydd. Llangwn, Usk.	Sunny Bank. Rhiwderin	Croesheolydd. Bassaleg.	Llanddewi Court. (Perry Orchard).	The Hendre. Old Pandy Mill. Shirenewton. (Perry Orchard).
Surface Soil	%	%	%	%	%	%	%	%	%
Stones	..	..	..	13·00*	..	10·90*	8·50*	..	..
Fine Gravel	0·80	0·78	0·65	2·68	1·08	1·93	2·17	0·68	0·81
Coarse Sand	9·84	3·95	4·08	29·55	2·15	16·49	17·80	10·46	2·39
Fine Sand	38·86	23·13	27·61	30·36	29·34	34·70	30·82	35·09	26·63
Silt	19·34	25·63	26·60	13·14	23·68	15·96	20·01	18·30	27·69
Fine Silt	16·07	26·94	15·47	9·67	22·40	14·50	13·65	18·32	22·61
Clay	6·77	10·20	12·92	3·72	14·31	5·41	4·05	8·24	11·43
Sub Soil.									
Stones	..	..	..	17·60*	..	..	13·00*	7·00*	..
Fine Gravel	..	1·65	0·77	3·33	0·41	2·85	3·34	3·54	1·02
Coarse Sand	..	7·90	3·63	29·10	2·09	17·76	18·68	11·29	2·09
Fine Sand	..	29·68	29·64	31·52	25·06	33·48	29·67	35·63	24·99
Silt	..	19·82	24·83	17·23	23·90	12·99	18·54	14·90	27·14
Fine Silt	..	23·64	14·10	7·02	25·94	17·57	17·61	17·02	21·75
Clay	..	11·20	19·51	4·27	16·29	8·90	4·87	10·06	17·33

* Pieces of sandstone.

Surface Soil.	%	%	%	%	%	%	%	%	%
Moisture . .	1·60	1·85	2·79	1·99	1·64	2·20	2·11	2·17	1·97
Loss on Ignition .	6·31	7·41	7·86	7·64	4·35	7·49	8·40	7·02	6·10
Carbonate of Lime .	Nil	Nil	0·351	0·124	Nil	Nil	Nil	Nil	0·429
Phosphoric Acid (Total)	0·102	0·132	0·136	0·126	0·070	0·195	0·189	0·111	0·0811
Ditto (Available) .	0·0160	0·0079	0·0128	0·0198	0·0078	0·0345	0·0224	0·0145	0·0107
Potash (Total). .	0·568	0·700	0·841	0·387	1·02	0·569	0·357	0·574	0·848
Ditto (Available) .	0·0101	0·0095	0·0143	0·0178	0·0095	0·0163	0·0192	0·0041	0·0133
Lime Requirement .	0·401	0·328	Nil	Nil	0·146	0·693	0·675	0·211	Nil
Sub Soil.									
Moisture . .	..	1·22	2·98	1·29	1·51	1·63	1·40	1·42	1·95
Loss on Ignition .	..	4·40	4·08	4·16	4·27	4·18	5·11	4·50	4·28
Carbonate of Lime .	..	Nil	0·050	0·041	Nil	Nil	Nil	Nil	0·164
Phosphoric Acid(Total)	..	0·0841	0·079	0·0872	0·070	0·20	0·148	0·0865	0·0479
Ditto (Available) .	..	0·0024	..	0·0125	0·0080	..	0·0154	0·0107	0·0063
Potash (Total). .	..	0·581	1·052	0·372	1·29	0·552	0·357	0·556	1·01
Ditto (Available) .	..	0·0094	..	0·0159	0·0091	..	0·0105	0·0053	0·0065
Lime Requirement .	..	0·128	Nil	Nil	0·091	0·405	0·401	0·190	Nil

ADVISORY WORK.

The number of enquiries received during the year ending September 30th, 1920, was 291. The figures for the counties as well as totals and the corresponding figures for previous years are set out as below.

	Year ending September 30th.				
	1916.	1917.	1918.	1919.	1920.
Gloucester (including Bristol)	21	24	21	29	53
Hereford	9	6	2	6	10
Somerset	50	52	46	75	79
Wiltshire	10	4	0	6	3
Worcester	26	16	11	11	29
Other Areas (including Campden) ..	89	31	93	75	117
Total	205	133	173	202	291

The figures for " other areas " include Devon and Monmouth, which counties contribute an annual grant to the Institute.

Twenty-one enquiries were received from the Ministry of Agriculture's Experimental Station in Fruit and Vegetable Preservation at Campden, Glos. These being of an advisory nature are included in the total figures for 1920, and not in the figures for Gloucester. In previous years this figure did not appear.

Most of the enquiries were horticultural in nature, though a certain number of agricultural questions were answered as well.

Nature of Enquiries.

Fruit Products.—Some 60 replies were given under this head, the majority of them having to do with cider work. As showing the wide field from which enquiries on this subject arise, mention may be made that advice was furnished to correspondents in Ireland, Scotland, Isle of Jersey, Canada, New Zealand, U.S.A., and Manchuria. Three enquiries demanding special investigations and journeys were received namely :—

(1) The construction of glass lined cement tanks for cider.

(2) The rebuilding of a cider factory.

(3) The starting of a cider factory.

Campden Enquiries.—Twenty-one enquiries of a technical character passed on from the Ministry of Agriculture's Experimental Station on Fruit and Vegetable Preservation have been dealt with.

These have been concerned for the most part with matters arising in connection with various methods of preservation and the manufacture of preserves, as, for example, the estimation of the pectin content of fruit pulp, the preparation of fruit pulps rich in pectin, the use of a certain form of sugar syrup in jam-making, the analysis of jams, the use of sodium bicarbonate to neutralise excessive acidity in preserves, the preservation of fruit pulp by calcium bisulphite, and vacuum processes for fruit and vegetable drying.

Mycological.—Some sixty-six replies were given under this head, most of them referring to fairly well known diseases. The outstanding feature of the diseases in the advisory province was the severe damage wrought by the chocolate spot of beans. This disease, which is probably bacterial in nature, caused great losses in Hereford, Somerset and Wilts. The spread of the disease was very rapid and in severe cases the haulm was reduced to a black rotting mass. The disease would appear to occur to a certain extent every year, but the weather conditions of 1920, were so favourable to it that the disease assumed epidemic proportions. The bacterial disease of plums, noted last year, was reported again from the same source, and since then specimens of the disease have been received from Somerset, Hereford and Monmouth. The disease is now the subject of investigation. A disease of Michaelmas Daisies reported from Worcestershire, and since identified in three places in Somerset, has been under investigation. It is probably due to a vascular parasite of the Fusarium genus.

Pomological.—About twenty replies were given under this head including such subjects as apple stocks, identifying varieties, suitability of land for fruit tree planting, books on fruit growing, effects of grass on trees, identification and treatment of weeds, etc. Questions on pruning and ringing of apples are not included here, but referred to under the Entomologist's report.

Shows.—An exhibit from the Station was sent to the following shows :—

(1) The Bath and West at Salisbury.

(2) The Royal Horticultural Society at Cardiff.

(3) The Pershore Fruit Growers' Association at Pershore.

Agricultural Chemistry.

During the year 36 requests for advice have been dealt with. The sources and nature of these enquiries—together with any special points of interest with reference to them—are given below.

SOURCES OF ENQUIRIES:

Gloucester (including Bristol)	14
Hereford	2
Somerset	9
Wiltshire	0
Worcester	1
Counties outside the Bristol Province	10
Total	36

NATURE OF ENQUIRIES.

1.—*Soil Problems.*

(*a*) *Soil Manurial Enquiries.*

Pastures and meadows	4
Arable soils	7
Fruit soils	2
Garden soils	3
Total	16

(*b*) *Miscellaneous Soil Problems.*

Advice re laying down of pastures and temporary leys	2
Advice re suitability of land for fruit growing	1
Enquiry as to reasons for strawberry failure	1
Condition of soils in cases of Club Root disease	2
Examination of soils on which plants were apparently suffering from Chlorosis	1
Survey of fields in which soils were suspected of containing lead	1
Soil conditions in case of clover sickness (Sclerotinia disease)	1
Enquiry into case of Leaf Scorch	1
Total	10

2.—*Miscellaneous Enquiries.*

(1) Analysis of sample of " night soil."
(2) Dry matter in a sample of mangels.
(3) Use of guano as manure for arable land.
(4) Dry matter in two samples of swedes.
(5) Use of burnt lime as a fertiliser on rough grassland.

(6) Manurial value of two samples of flue dust from electric works.
(7) Determination of "hardness" of sample of water to be used in soap sprays.
(8) Manurial value of leather clippings.
(9) Value of a South African shale as a fertiliser.
(10) Manurial value of some radio active residues containing "radio-thorium."
(11) Manurial value of wood ashes from burnings made on a farm.
(12) A case of "scouring" among cattle.

Total 12

Observations on Soil Enquiries.—In dealing with these enquiries twelve visits to Farms have been made and it has been necessary to make partial or complete analyses of fifty-one samples of soil. Twenty-four of these samples were found to have "Lime Requirements" and in eight cases the "Lime Requirements" exceeded 0.3% Ca $C0_3$. Particulars of these high "Lime Requirements" are given below.

Nature of Field.	Locality.	Lime Requirement %Ca Co_3.
Old Pasture.	Yate, Gloucestershire.	0.434
* Arable	Lydney, ,,	0.50
* do.	Mendips, Somerset.	0.419
* do.	do.	0.545
* do.	do.	0.775
* do.	do.	0.90
* do.	do.	0.30
Old Pasture	do.	0.860

Special Investigations Undertaken as the Result of Enquiries.

Five "Special Investigation Problems" of a more or less purely chemical nature have been undertaken, two of which have been completed, two are to be continued during next season, and one has been set aside to be dealt with more fully at some future date.

Details of "Special Investigations."

(1) Survey of the soils of six fields suspected of containing lead, on a farm situated on "The Mendips," Somerset.

The farmer had lost eight cattle from "Lead poisoning" during the previous season. Samples of soil from various parts of six fields suspected of containing lead were tested for lead, and the soil in one of the fields was found to contain lead in considerable

* Denotes newly "broken up" pastures.

quantity. It is hoped that an opportunity will occur in the future of making a detailed survey of the "Lead Soils" in this district, as several fields in the district are known to contain lead.

(2) Enquiry as to the cause of a case of Chlorosis at Winscombe, Somerset. (Joint investigation with Botanist of Research Station.)

Four samples of soil from affected areas were taken for qualitative tests. Three of the samples appeared to be similar, containing large amounts of carbonates, whilst the remaining sample appeared to contain only a normal supply of carbonate (about 1% $CaCO_3$.)

Two of the soils—one with high carbonate content, and the one containing normal amount of carbonate—were tested for the presence of toxic metals, and determinations of their lime (CaO) and magnesia (MgO) contents were made.

Results.

(*a*) Only metals normally present in fertile soils found.

(*b*) Soil with high carbonate content—
%CaO 12.83—%MgO 2.68.

Soil with normal carbonate content—
%CaO 1.57—%MgO 2.05.

Pot experiments have been carried out in which samples of the four soils have been sterilised by heating to 120°C., and subsequently inoculated with about one-tenth of their weight of soil taken from a plot at the Research Station.

Two crops—1st Mustard, 2nd Tomatoes—have been grown in these treated soils and in samples of the soils not previously treated.

Results.

	Treated Soils.	Untreated Soils.
Mustard Crop.	Vigorous growth. No signs of chlorosis in any pot.	Fair growth. No distinct chlorosis in any case.
Tomato Crop.	Growth poor. Chlorosis distinct on plants in three soils with high carbonate content.	Growth very poor. Chlorosis distinct on plants in three soils with high carbonate content.
	No chlorosis in soil with normal carbonate content.	No chlorosis in soil with normal carbonate content.

It is proposed to continue this work during the coming season.

(3) Pot Experiments on mustard and lettuce plants to ascertain the manurial value (or otherwise) of some radio-active residues in which the radio-activity is due to the presence of radio-thorium.

A preliminary experiment has been carried out on mustard and

lettuce plants to obtain indications re amounts of the residues to use, etc. It is hoped to be able to obtain a definite result during the coming season.

(4) An investigation into the composition of " Nitre Bearing Shale " from South Africa with reference to its value as a fertiliser.

This shale is said to contain quantities of potassium nitrate varying from 1 or 2% to 25%.

The two samples examined were brown in colour and had been ground to fine powders.

The results of the analyses are given below :

Sample I.

Qualitative Analysis.		Quantitative Analysis.	
			%
Water soluble constituents.		Moisture	3.68
Metallic Radicals present	Acid Radicals present	Loss on Ignition	10.02
Calcium	Sulphuric	Insoluble in water (earthy matter)	84.98
Magnesium	Nitric	*Water soluble constituents.*	
Potassium	Hydrochloric	Potash (K_2O)	3.74
Sodium		Nitric Acid (NO_3)	5.35

Sample II.

Qualitative Analysis.	Quantitative Analysis.	
		%
Water soluble constituents.	Moisture	3.88
Metallic and Acid Radicals as in Sample 1.	Loss on Ignition	10.64
	Insoluble in water (earthy matter)	83.89
	Water soluble constituents.	
	Potash (K_2O)	4.03
	Nitric Acid (NO_3)	5.6

(5) The Potash Content of " burnings " made on a farm.

These samples were taken from the ashes of routine burnings in connection with the ordinary cleaning of fields and hedges.

Materials Burned.	Appearence of Sample.	% Potash (K_2O) Present Sol. in Dilute HCl.
1. Hedge Trimmings.	Appeared to be good sample of burnt twigs.	1.44
2. Couch Grass.	Contained much soil.	0.56
3. Hedge Trimmings and Couch Mixture.	Contained much soil.	0.40
*4. Thistles and Rough Grass.	Appeared to be an excellent sample.	22.93

* About one bucketful of ashes of this quality were obtained from burning one cart load of material.

In addition, work has been done in connection with two other special problems mentioned elsewhere in the general Advisory Report.

Economic Entomology.

The subjects dealt with were as follows :—

Insects	35
Sprays	9
Diseases	10
Fruit Questions	10
Miscellaneous	1

Under the heading " Insects " all other economic groups such as Myriapoda, Arachnida and Mollusca are included. Of special interest under this heading may be cited the common attack of Mangolds by Turnip Flea Beetles, also an attack of Mangolds by a larva of a beetle of the genus *Silpha.*

A case of flax attacked by *Longitarsus ater* was reported from Somerset, but no action was taken as the attack had nearly spent itself at the time of investigation.

" Diseases " indicates maladies other than those caused by fungi and insect pests. Of these ten enquiries, six referred to " reversion " of black currants and three to leaf scorch. Both these subjects are referred to in the Research Report.

Of special interest is a newly reported disease of strawberries known as " red leaf." This has been sent in by the Tamar Valley growers, where it is said to be causing much trouble. At the present moment nothing can be said as to its nature or cause.

Among the " fruit questions " those referring to pruning and the practice of ringing may be mentioned. These are the direct outcome of research work on these subjects done at Long Ashton.

Visits.

A special visit was made to Norfolk and other districts in East Anglia in connection with reversion of black currants. Besides affording an opportunity to communicate to eastern growers the results so far attained in research work, the visit enabled valuable comparative data for the different climatic conditions to be obtained.

General advisory visits were made to Worcestershire and Herefordshire.